THE

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THE

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ELECTROLYTIC TROUBLES IN ELECTRIC TRACTION.

MR. FARNHAM, who has made a special study of the electrolytic effects of large earth return currents, such as are used on electric railways, brought up the subject in very complete form before the American Institute of Electrical Engineers, and a very interesting discussion resulted.

The large currents flowing back through earth have been proved to be continually corroding every metallic mass which comes in their path. Examples of iron gas and water pipes and lead sheathing on wires were exhibited, showing complete destruction. The currents used in New York, Boston, and elsewhere in American electric railways are far beyond anything we have any experience of here. On a British electric railway, the use of 900 ampères is spoken of as a large system; but in America thousands of ampères have to be dealt with on one line, so that the effects are more rapid, and therefore sooner become apparent.

The first point which presents itself is what effect the different poles have compared with each other. It seems if the negative pole is earthed, the destruction is concentrated upon pipes and cables close upon the railway, but if the positive pole is earthed the electrolytic effects are more widespread and slower.

With the negative pole earthed, one would not at first sight expect much action; but these large currents in parts enter and leave the metallic masses at many points, and every entering point becomes a cathode and every leaving point an anode, no matter what may be the earthed poles; but it seems preferable to confine the electrolytic effects within the narrowest possible compass, and therefore the practice is to connect the negative to earth.

Some of the speakers in the discussion seemed to think that with alternating currents all this trouble would disappear. We are not so sure of that; we know of such a thing as alternating current electrolysis, and have seen a good deal of damage done to metals under its influence.

Measurements have been made with a view to ascertain the voltage at work on the metallic bodies affected underground by the return current, but very small differences of potential were observed. We don't place much reliance on such measurements. It is exceedingly difficult to devise a method of measuring the actual voltage at certain given points in an electrolyte containing detached conducting bodies; but as might be expected, very small differences were observed—·01 to ½ a volt; but these differences of potential are not to be taken as the measure of the forces at work in electrolytic actions.

Prof. Houston referred to this low voltage ascertained, and raised the difficulty that lead required over 2 volts to oxidise it in a storage cell; but lead is acted upon by a

pressure much less than 1 volt, although not peroxidised. The fact of the matter is, the term electrolysis is altogether misapplied when used as it has been in this discussion. In reality, it is not electrolysis which is under discussion at all, but electro-chemical effects on metals. An electrolyte of a definite composition requires a definite voltage to split it up between an anode and a cathode of platinum. A solution of water and sulphuric acid between platinum plates requires about 1·5 volts to split it up, but between lead plates a smaller voltage would split it up, between iron plates still smaller, and between zinc plates less still would be required. The affinity of the metal comes in.

The actual difference of electric pressure required to split up a compound or effect an electro-chemical union—*i.e.*, corrosion, is exceedingly small with some electrodes, while it is great with others—an iron pipe or lead pipe in moist earth is always just on the point of corrosion, so that the slightest additional force in the shape of electric pressure at once determines vigorous action.

The smallness of the differences of potential actually observed is of no importance, as the various metallic masses in the earth set up differences themselves, and are ready for action on the slightest additional extraneous force being added to their own.

In discussing these matters, it might be well to draw a distinction between electrolysis pure and simple and electro-chemical action. Electrolysis is a term which might be confined to the splitting up of compounds between electrodes which are not themselves acted upon, such as decomposing water between platinum plates; electro-chemical action is that wherein one or both electrodes enter into the action, and are combined with, or decomposed by, the electrolyte. In the one case we know exactly the actions, forces, and quantities, by the laws of electrolysis; in the case where the electrodes themselves enter into the action, the laws of electrolysis still hold good, but the results are not so easily arrived at, as secondary effects take place.

One proposal made is to thoroughly bond the rails and connect to a return earthed wire as a supplementary return to the rails, but it has been found that this supplementary return cannot be maintained in good connection.

Another proposal is to make the lines of pipes good conductors; but that is impossible. Prof. Elihu Thomson proposes sub-stations with motor generators at frequent intervals along the line, so as to provide a short return path, the sub-stations to be fed by high pressure metallic circuits.

Electric welded rail joints instead of fish plates are recommended by others. A three-wire railway system has been proposed with the neutral wire only to earth; this plan has some drawbacks, but is on trial at Bangor, Maine. We shall refer at another time to this three-wire scheme.

The double trolley seems to be really the only perfect cure, but it introduces terrible complications in street railways at crossings and curves. An advocate of the double trolley, however, made out a good case for it, and some of his figures given here may be of interest.

"In considering the return system for an electric road, the railway company should not forget that, by providing an adequate return circuit which will protect other underground structures, they are not only securing immunity for themselves from damage suits, but at the same time are putting more money into their pockets in a saving of coal pile, than the interest and the depreciation upon the investment involved in the return circuit will amount to.

"In working some 300 miles of electric road, it has been found that the grounded return circuit absorbed more energy from the station than any other part of the line, the car motor only excepted. In one instance the return circuit of the road was so poor, owing to defective rail bonding, and the dry condition of the soil, that, in many instances, the rail bonds had actually burned their way through the ties of the road, and allowed the rails to separate.

"In another instance motor repairs were reduced several hundred dollars a month by the addition of an appropriate amount of feed wire supplementing the return.

"In a third case the amount of power required for operation was reduced by 80 H.P. by the provision of an appropriate return."

Mr. Kennelly referred to the earth resistance also, and stated that it was really far higher than the value we ordinarily attribute to it. In telegraphy and telephony we are so accustomed to employ good earth as a low resistance, that unconsciously we come to leave the earth return out of our calculations, and so we safely may with the infinitesimally small currents used in telegraphy and telephony, but when it comes to thousands of ampères the resistance of the earth return assumes some importance, and the $C^2 R$ loss in it must come up to a considerable figure.

ELASTIC "FATIGUE."

The present number of the *Physical Review* contains the results of some experimental researches on the longitudinal and torsional elastic "fatigue" of wires, undertaken by Mr. Louis W. Austin, in the laboratory of Prof. Kohlrausch, at the tower of the College of Physics, in Strasburg. Special precautions were taken to eliminate errors of grip, slip, and temperature, the readings being made in the ordinary way, with telescope and scale.

The accurate observation of "fatigue" is rendered extremely difficult from the fact that even a small weight applied for a sufficient length of time to a wire will produce a permanent set; from this cause, any positive conclusions in regard to the similarity of results for different degrees of strain, or during strain and after release from strain, is impossible. Kohlrausch, during his observations on rubber, found that the results were more nearly congruent as the stretching weights were made smaller, the permanent set ultimately tending to a minimum; so that for small, but different, strains, curves drawn up for the same material should be practically of similar form. In the tests made by Mr. Austin, a greater amount of fatigue was found for a given strain on copper than with the other metals investigated; its low limit of elasticity made it necessary to use smaller weights, for the reason just given. His observed values are in very close agreement with the values calculated from the formula of Kohlrausch; the fact, however, that the fatigue does not increase at the same rate as the strain which produces it, in copper, makes the comparisons between individual tests at various torsions unsatisfactory.

The results have gone to show that the fatigue resulting

from long periods of tension, disappears in about the same time as that which is required to produce it. The longitudinal fatigue, in general, seems to follow the same laws as the torsional; it is nearly proportional to the deforming strain; the curves which represent its disappearance are similar, so long as the time of strain is short; the curve sinks more slowly as this time increases. The fatigue in copper, silver, and brass, are to each other nearly as 7 : 3 : 2 for the torsion, and as 4 : 3 : 2 for the tension. The temperature co-efficient both for torsion and tension in all three metals seems to be not far from $\frac{1}{30}$th.

In regard to the course of the fatigue during long-continued strain, and after release from strain, the results are unsatisfactory, as all the wires appeared to take a permanent set if the strain lasted more than a few hours. The most that can be said is, that for small strains lasting for several days, the fatigue disappears in about the same length of time as that required to produce it; and, if the strain is very small, the two curves take nearly the same course.

From the observations on silver wire, it seems that in general the fatigue is entirely independent of the diameter of the wire. The experimenter hopes, within a short time, to publish further results in regard to the effects of temperature on the fatigue, and also on a possible relation between the elastic limit and the time of strain.

Long Distance and Submarine Telephony and Rapid Telegraphy.

Prof. M. I. PUPIN, of Columbia College, America, evidently thinks he has hit upon the right solution of this problem. Briefly, his method consists in dividing up the cable into sections and connecting the sections by condensers. Leaders are devoted to the subject in the electrical papers. It seems hardly necessary to say that the arrangement is old, is founded on fallacies, and instead of increasing working speed tends to do exactly the reverse. Why do not inventors try their inventions practically before patenting or publishing them? A trial of the fast (?) speed system on an artificial cable would, we are afraid, humiliate the poor Professor and dispel his hopes. The patent may, as stated, be written in "clear, logical, and scientific language" but the idea won't work for all that. It is not a question of opinion but of stubborn fact.

Litigation in America over the Incandescent Lamp.

TWO appeal cases have lately been heard and decided in the U.S.A. on this oft disputed subject. In one of the cases the decision was given in favour of the owners of the Edison patent, and in the other it was given against them. The former was an appeal by the Electric Manufacturing Company, this company having last year received an injunction, at the instance of the General Electric Company, restraining it from manufacturing incandescent lamps. The appellants introduced no novel point in their appeal, the chief argument being that in consequence of Goebel's claimed anticipation of the incandescent lamp the claim in the Edison patent should have a narrower construction put upon it. Judge Jenkins, who decided the case, however, agreed with the majority of judgments that have been given where the Goebel claims have been advanced, holding that even if the story should prove on final hearing to be true, it appears at present to be so improbable that "the claim ought not to be permitted to invade the monopoly accorded to another for the same invention, whose claim has passed safely the ordeal of judicial scrutiny." The other case was brought by the Edison Electric Light Company against the Buckeye Electric Company, a preliminary injunction being demanded. It appears that last year the Buckeye Company was restrained from manufacturing lamps, but that at a later date the restraining injunction was dissolved by reason of certain acts on the part of some of the plaintiffs in their application to the Patent Office, which acts limited the duration of the Edison patent to November, 1893. The case advanced by the Edison Company was of a rather complicated nature. The Edison patent has, at different periods in its existence, been owned by various parties, and the present owners claim that they should not be held responsible for what Edison and the owners of the patent did in 1883. Judge Ricks, however, pointed out that the weak point of their case was that it was nowhere affirmatively claimed that the present plaintiffs were ignorant of and did not participate in the several acts which it had been held estopped the other plaintiffs from claiming relief against those defendants. The motion for a preliminary injunction would therefore be refused.

An Electric Method for Heating Gases.

IN a recent investigation relating to the composition of the gaseous envelopes of the sun, and in which it was necessary to heat gases such as oxygen to a high temperature, Mons. J. Janssen had recourse to electricity, having failed to obtain good results with other methods of heating. The gases were enclosed in strong steel tubes closed at the ends with quartz and containing spirals of platinum wire suitable to the length of the tubes and to the power of the source of electricity. The wire was electrically insulated from the sides of the tube by means of asbestos fibre: this substance also opposed the transmission of heat from the spiral to the sides of the tube. The ends were also insulated. This ingenious, yet simple arrangement, provided the necessary means for quickly raising the gases to very high temperatures—temperatures, too, which could easily be deduced electrically. The apparatus and the experimental results obtained with it are described in a recent number of the *Comptes Rendus*.

An Elementary Expression in Thermo-Electrics.

IT has frequently been observed that the thermo-electric equation, due respectively to Avenarius and to Tait, does not reproduce the observations satisfactorily when long temperature ranges are dealt with; indeed, Prof. Tait does not claim that it will do so. Within an interval of a few hundred degrees however, the equation is usually in accord with the experimental results. It is desirable, therefore, to find a more general relation from which the Tait equation may be derived as an approximation. This is the object of a paper by Carl Barus in the May issue of the *American Journal of Science*, and he endeavours to elucidate the subject without explicit reference either to the Peltier or to the Thomson effect, and in a deductively experimental way. In arriving at his results, use was made of a previous research, in which Dr. Stronhal was also engaged, upon the relation between the thermo-electric power and the specific resistance of steel varying with hardness. The results were not employed, but the suggestions which were the outcome of this investigation proved valuable, as were also the conclusions deduced from an enquiry into the thermal variation of the resistance of an electrolyte. The expression ultimately reached for Tait's thermo-electric equation was

$$E = (\theta - \theta_0)(A^2 \pm A'^2)\,\epsilon_n \left\{ -\theta_m + \frac{\theta + \theta_0}{2} \right\}$$

when θ, θ_0, and θ_m, are respectively the temperatures of the hot and cold junctions, and the temperature at which E is a maximum or minimum. A, and A', the specific constants of the metals, and ϵ_n the thermo-electric condition of one of the metals at the neutral temperature. It is probable that von Barus will still further pursue this subject, proceeding from a different point of view and taking advantage of the notions of vant' Hoff.

THE HUMMEL ELECTRICITY METER.

We are about to describe a new meter, says "E. V.," in *L'Industrie Electrique*, the Hummel meter (fig. 1), which is used in several towns in Germany, and which seems to us to fulfil the requirements expected from these apparatus.

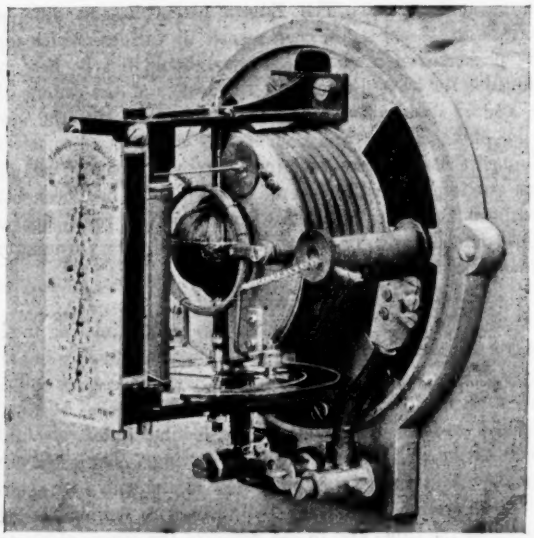


Fig. 1.—The Hummel Meter.

In principle it consists of a little electro-motor, the field magnets of which are in series on the principal circuit, whilst the armature is connected in derivation on the circuit, and a copper disc in which the movement of rotation is counteracted by the Foucault currents produced in it.

The plan of the circuits is shown in fig. 4.

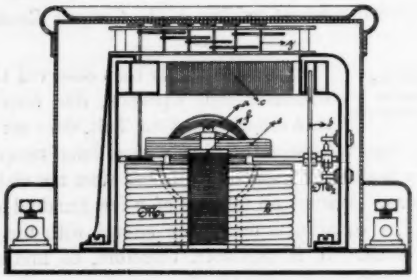


Fig. 2.—Section of the Meter.

M is a little electromotor of which the armature, *a*, and the electro-magnets, *b*, do not contain iron, in order to avoid the errors due to the variation of the magnetism in the masses of iron. The prolongation of the axle of the motor supports a copper disc, *c*, which revolves before the poles of an electro-magnet, *d*, in such a manner that the Foucault currents produced in the disc shall act as a brake upon it. Following the circuits we see that the principal current only traverses the winding of the inductive system before arriving at the consuming apparatus, represented in fig. 4 by lamps. The other parts of the apparatus are arranged parallel to the circuit of the lamps; they thus receive a derivation from a current, the tension of which is, in general, constant, and on which they are grouped in series, viz., the armature, *b*, the retarding electro-magnets, and a resistance.

The armature is spherical, but hollow.

The readings are taken, as in the Aron meter, by means of five dials; units being recorded on the top dial, tens on the next, and so on.

The difference between the readings before and after the service must be multiplied by a constant varying with each apparatus, which is not very practical for the consumer. However, up to the present this constant has been as a rule equal to one or some whole number, so that the ampère-hours could be read directly. The errors that are possible are unimportant, as can be seen by the two diagrams (figs. 5 and 6).

We can see that the error found did not exceed one per cent., and that these apparatus are so sensitive that only 1·5 per cent. of the normal current is required to start them.

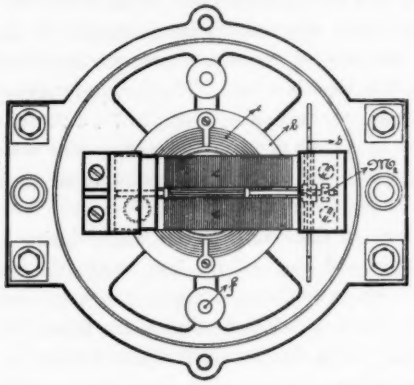


Fig. 3.—Plan of the Meter.

Thus the apparatus satisfactorily fulfils the requirements of practice in this respect.

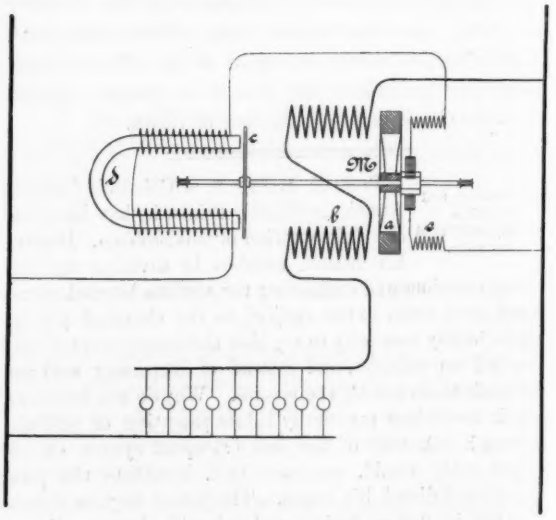


Fig. 4.—Diagram of the Meter.

At 100 volts the meter only absorbs ·5 ampère. The expenditure is then only 5 watts.*

The following explanation will suffice to show the theory

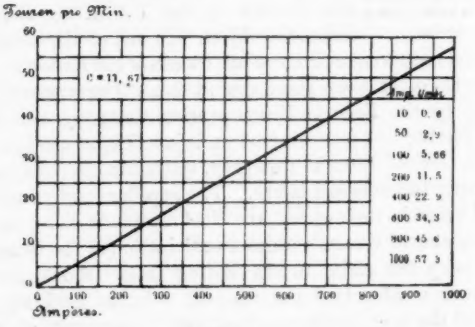


Fig. 5.

and working of the apparatus. Designating i the variable intensity of the current to be measured, the total quantity of energy supplied, Q, is equal to the expression of that intensity as a function of the time, *i.e.*, we get

$$Q = \int i\,dt.$$

But from the above description it follows that the power produced, P, by the motor at each moment is in proportion to

* This is correctly translated, but of course the figures should be either ·05 ampère, or 50 watts.—Eds. Elec. Rev.

the intensity, i, of the exciting current of the inductor and the speed, v, of the armature, since the intensity passing through this armature may be considered constant.

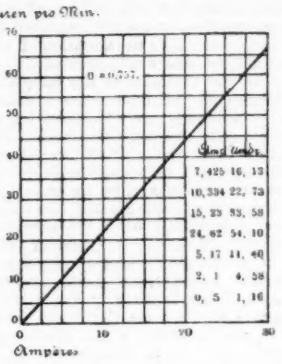


Fig. 6.

On the other hand, the power, P, absorbed by the copper disc is also proportional to its speed, v, and to the intensity, j, of the Foucault currents induced in this disc. We can, therefore, state that

$$P = i\,v = P^1 = j\,v\,k, \text{ if } k \text{ is a constant.}$$

The intensity of these eddy currents being also in proportion to the speed of the disc, or at each moment $i\,v = c\,v^2$, c being another constant, the speed is, at each moment, in proportion to the intensity of the exciting current.

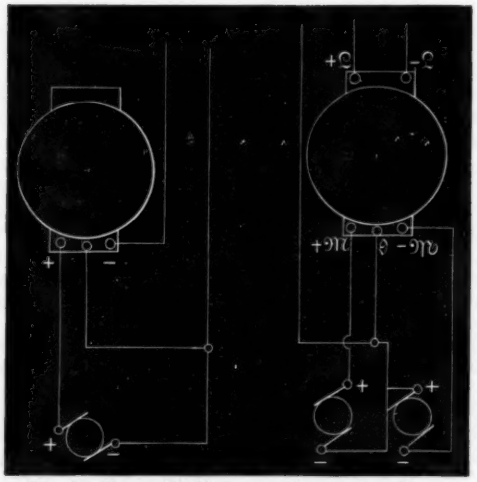


Fig. 7.—Two-wire Meter. Three-wire Meter.

From this it follows that the space traversed by any point whatever of the copper disc, and which is deduced from the number of revolutions of the latter, is in proportion to the quantity of current supplied, so that the mechanism for summing up can indicate this quantity at once.

The connections of this meter can be arranged for either two-wire or three-wire distributions (fig. 7). The external appearance of this meter is suited to industrial requirements, but the fixing of it requires great care; the axle being vertical, violent shocks must be avoided in order that the readings may not be falsified.

HERMITE ELECTROLYTIC SANITARY PROCESS.

A Special Analytic Sanitary Commission has delivered a report on this process to the *Lancet*, founded on the recent experiments at Worthing.

The report commences by stating that only the magnesium chloride is decomposed, as it is in excess, and is far less stable than the sodium chloride, which is said to act merely as a conductor. We take an analysis from the report, showing the changes made in the components of sea water when subjected to Hermite's process :—

Analysis 1.

Electrolysed sea water.*—Parts per 1,000.

Calcium sulphate ($Ca SO_4$)...	1·392		
Magnesium sulphate ($Mg SO_4$)	2·325	=	0·775 Mg O
Magnesium chloride ...	2·868	=	1·195 Mg O
Sodium chloride	27·700		
Total solids	34·285	containing	1·970 Mg O

Analysis 2.

Untreated sea water.—Parts per 1,000.

Calcium sulphate ($Ca SO_4$)...	1·400		
Magnesium sulphate ($Mg SO_4$)	2·300	=	0·765 Mg O
Magnesium chloride ...	3·670	=	1·545
Sodium chloride	27·060		
Total solids	34·430	containing	2·31 Mg O

* Oxidising value of liquid in terms of chlorine, 0·594.

A glance at the amounts of constituents in the two fluids will show at once that the only important difference between them is that a sensible loss of magnesia calculated as oxide has occurred in the electrolysed fluid. (To enable our readers to see this difference more clearly the quantities of Mg O corresponding with the salts indicated have been calculated and placed to the right of the columns.) According to this analysis, therefore, there has been a loss of magnesia (Mg O) in the electrolysed fluid equal to 2·31 *minus* 1·97, or 0·34 gramme Mg O per litre.

In the untreated water we find magnesium compounds equal to 5·970 parts and sodium compounds equal to 27·060; in the treated water we find 5·193 of magnesium compounds and 27·7 of sodium, a difference of 0·777 in the magnesium and of 0·540 in the sodium compound. These figures certainly do not prove that only magnesium compounds are acted upon, but show that the sodium chloride plays more than the part of a conductor.

Of course, as we should expect, the magnesium compounds are acted upon to the greatest extent. Magnesium oxide and chlorine are set free, also a small quantity of caustic soda and chlorine from the sodium chloride, but by means of the revolving anode the metallic oxides are immediately brought into contact with the free chlorine forming hypochlorites, principally of magnesium, and the solution should show an alkaline reaction, whereas it is neutral, but has powerful bleaching properties; instead of turning litmus blue it instantly bleaches it. On this point the report says :—

In the Hermite fluid, however, we have not to deal with an alkaline fluid; indeed, we have obtained some evidence which serves to show that the active body in it is not magnesium hypochlorite in important quantity, as some have supposed, but hypochlorous acid itself. We may refer once more to Analysis 1 of electrolysed water where it is contrasted with untreated sea water. As is there pointed out, the chief difference to be noticed between the two analyses consists in an important diminution of the total magnesia (Mg O). Now a substance is deposited in notable quantities in the electrolysing tanks and along the pipes conveying the fluid to the service cisterns, which proves on examination to consist of impure magnesia. This would at once explain the difference. Whatever change takes place on electrolysis, there is evidently a subsequent dissociation of a magnesium compound, and the probability is that this compound is magnesium hypochlorite, for it is magnesium chloride that is decomposed by the current into chlorine and magnesia, and these probably reunite on circulation, forming hypochlorite in accordance with the equation $2\,Mg\,O + 2\,Cl_2 = Mg\,Cl_2 + Mg\,Cl_2\,O_2$.

This fully supports the contention of our original views expressed in the article written by our commissioner to Worthing, as do also the following opinions on the process, which the report goes on to express thus:

We have shown in the foregoing results that electrolysed sea water contains probably as its chief active constituent hypochlorous acid, resulting from the partial dissociation of magnesium hypochlorite, and that it is fairly stable under ordinary circumstances; that it is a powerful bleaching liquid, being superior in this respect to bleaching powder solution, but not to a solution of bleaching powder of equal chlorine value, in which the hypochlorous acid has been liberated by the addition of a weak acid (CO_2 or others, in weak solution); that it is also a powerful deodoriser, and that in all probability these properties are due to the united action of oxygen *in statu nascendi* and chlorine. These, in brief, are the chemical properties of electrolysed sea water, and it remains for us to consider what effect for good or for evil such a liquid of definite strength would have when mixed in a certain proportion with fæcal matter. It deodorises, but does not destroy or remove, organic matters, although there is little doubt that certain of them are partially changed, and most probably those which are more readily putrescible (*vide* the analysis of effluent). While these things are true, and are so far satisfactory, there must also be certain drawbacks in the system which are likewise indicated in these experiments. Electrolysed sea water, for instance, is rapidly reduced in strength by common newspaper, and as this is an almost invariable accompaniment of human dejecta, its presence in the sewer must seriously affect the activity of the liquid, even if it does not with-

draw the active constituent entirely. Indeed, the entire contents of a sewer rapidly appropriate the chlorine strength of the liquid. The same observation applies to soap or domestic waste, &c., which rapidly "kills" oxygenated chlorine compounds. Again, it can only be supposed that deodorisation, not to say sterilisation, is complete when the chlorinated body is in excess, and an effluent containing free chlorine, or its equivalent, is inadmissible to rivers. The expense, moreover, in inland towns would be greater, since it would be necessary either to carry sea water, or to prepare it artificially. M. Hermite's proposal is to establish a producing centre in the towns, and to supply the liquid through pipes into all the streets and houses, much in the same way that water and gas are at present supplied. The adoption of such a scheme in any place would no doubt lead to a sanitary condition of things hitherto unreached; but many excellent advances could be made in the same direction, it should be remarked, if cost were not an item which so often bars the way. Apart, however, from such a scheme, there is no doubt that the production from sea water of a powerful bleaching agent and deodoriser is an innovation which should afford very material aid to sanitary progress. Thus, for many purposes, the substitution of electrolysed sea water for other and more expensive agents in our seaside towns and villages would doubtless confer many advantages. It could be used, for example—with desirable effect, doubtless—to flush the headings of drains and sewers; it could be discharged into sewage outfalls; and lastly, the system could be applied on a small scale for the sanitary treatment of hospitals, barracks, &c., by means of an automatic electrolyser worked from a central electric supply. It should be added that, except as regards what has already been published in our columns, no particulars in regard to the actual cost of production have as yet been furnished by the originator of the main idea.

We could offer no opinions regarding the sanitary value of the process, pending tests for the purpose of ascertaining its effects on sewage and micro-organisms; the tests reported upon all go to prove that the Hermite solution is a powerful agent in destroying disease germs, and for general sanitary purposes, as may be gathered from the following :—

In the case of the bleaching powder solution it is at once apparent that the immediate action on the organisms present is not nearly so great as in the case of the Hermite solution, where, even in five minutes, the majority of the organisms present (probably all those vegetative forms which were freely exposed to its action) are at once killed off. When, however, allowed to act for a longer period in the case of the stronger solutions the final result obtained was very similar; this is what we might naturally expect when we consider the chemical nature of the two solutions. In the case of the Hermite solution the available chlorine is present, in great part at any rate, in a free or only weakly combined condition, whereas the bleaching powder solution appears to give off its chlorine much more slowly, owing to its probably having first to undergo a process of chemical decomposition before it comes into operation. The great chemical difference in the activity of the two solutions is at once made manifest if we test their bleaching action on blue litmus paper. In the one case a bleaching action shows itself at once, whereas in the other none will manifest itself unless the active ingredients are set free by the addition of carbonic acid gas or some other acid. On the other hand, it must be mentioned that we have on several occasions met with other organisms which, so far as we have been able to investigate them, appear to form no spores. We have never, however, obtained colonies of bacterium coli communis (the characteristic organism occurring in stools) from the samples taken in Yard B; this we regard as a fact of the utmost importance from a practical point of view, for if this organism is unable to escape the action of the Hermite solution, it is exceedingly improbable that bacillus typhosus, or still less the bacillus of cholera or diphtheria, would be able to run the gauntlet.

If we compare the action of the Hermite solution as an antiseptic with carbolic acid, the superior efficiency of the former is so evident, even in solutions of relatively great dilution, that we are left in no doubt as to which is to be preferred. The only substance used as an antiseptic, which operates in solutions of such great dilution, is corrosive sublimate, $HgCl_2$, and, although the laboratory experiments might appear to give it a certain advantage, we are confident that the facility with which it unites with organic bodies, and thereby becomes inert, would render it very much less efficacious than the Hermite solution for general use as a practical disinfectant. The electrolysed sea water or our "artificial" Hermite solution appears, indeed, while exerting a specific disinfecting action on the organisms, at the same time to be used up and destroyed to a much less extent by the organic matter present than any other disinfectant with which we are at present acquainted.

In applying the results which we have obtained from our examination of the Hermite system carried out on the spot and our more extended laboratory experiments, it must first be stated that all investigators who have occupied themselves with the question of the sterilisation of stools have found it most difficult to render them absolutely sterile in a short space of time by the ordinary means available, and have accordingly addressed themselves more to the solution of the problem of what would be sufficient to free them from the pathogenic germs, such as those of typhoid fever and cholera, which might be present. We are quite satisfied from our examination of the effluent in Yard B that all such would be effectually dealt with, as the more resistant bacterium coli commune appears to be destroyed. It is probable from a number of observations which we have made, which it is unnecessary for us here to record, that the titrations of the effluent do not really indicate fairly its antiseptic power, but that this is really much greater than the arsenious acid method would lead us to expect. It will also be noticed that the higher strengths of solution supplied from the distribution tanks do not so markedly raise the amount of available chlorine in the effluent as might be expected, and this is to be accounted for by the more unstable portion of the solution being at once converted into some other form, which, although not indicated by the arsenious acid titration may still be effective as an antiseptic. The bacteriological results also are not improved to such an extent as to warrant us in recommending the adoption of such strong solutions of the Hermite fluid, as this would necessarily entail no inconsiderable addition to the cost involved in the adoption of the system; a strength of between 0·50 and 0·60 gramme chlorine per litre is all that we should consider necessary to effect the proposed objects of this method of sewage treatment. The adoption of any mixed system in which the house water, even without the storm water, is allowed to enter the drum in which the sewage undergoes treatment must, so far as we can see at present, always be accompanied by the danger that the whole object of the scheme may be rendered futile from the fact that we must rely wholly upon the care and judgment of the inmates of the household for the addition of sufficient quantities of the antiseptics from the sink. The application of the solution for watering the streets does not, we think, require serious consideration. The question of the flushing of the drains requires, however, further investigation, as, although the direct antiseptic action would probably be small, the deodorising and cleansing effects might have some value, but this can only be decided by direct experiment. The application of the system to hospitals in the complete form recommended by M. Hermite has much to be urged in its favour. The regular disinfection of all objects which have been exposed to contamination in the wards or in the side rooms by such a powerful disinfectant, which would always be at hand, must minimise the risk of the spread of infection which emanates from all such centres of disease. Its substitution in laboratories for the ordinary disinfectants now in use also follows as a natural consequence, and, inasmuch as what may be termed the "artificial" Hermite solution, can be made to any strength at an insignificant cost, whilst the electrolysed sea water can be raised to a strength of only a little over 1 gramme chlorine per litre, and this at an ever relatively increasing cost, it offers very obvious advantages for such purposes.

From all this it may be concluded that while the Hermite process may be too expensive to apply to common sewage purposes, it provides a solution far superior to most chemically-prepared disinfectants, and that its adoption in hospitals and other places would be of great benefit. In fact, it is not a process which appeals so much to the sanitary engineers, or Commissioners of Sewers, as it does directly to medical men.

The immediate application of the process seems to be the production of a cheap, powerful disinfectant, in large quantities for washing and cleansing purposes, and for occasional flushing of drains and sewers; and in the complete form it ought at once to be introduced into all hospital closets, sinks, drains, and for washing and cleansing. Its adoption in hospitals would be a great boon, would confer benefits far beyond the cost of its introduction in value.

An interesting point in the construction of the apparatus has evidently escaped notice hitherto. This is in the use of zinc cathodes in opposition to platinum anodes; these two metals have a potential difference of more than a volt in sea water, and this potential is opposed to the 5 or 6 volts of the dynamo, so that a volt at least of the dynamo pressure is lost simply in overcoming the potential difference of the two metals, platinum and zinc. Carbon could be used for the cathode discs without setting up any potential difference to speak of.

THE ELECTRIC STATION OF THE CITIZENS' LIGHT AND POWER COMPANY OF ROCHESTER, N.Y.*

By ROBERT CARTWRIGHT, M.Am.Soc.C.E.

(*Continued from page* 630.)

On Sunday, May 7th, an accident occurred that resulted in the carrying away of the west wall of the power room. A heavy freshet was running in the river, and the man having charge of the inlet gates to Brown's Race, by some miscalculation, allowed so much water to enter that it overflowed the old race wall at the company's property, and ran down and filled the pocket, P, fig 2, and, being confined between the rock and the wall, the hydrostatic pressure was great enough to throw the wall in large masses into the power room and wheel pit. The wall was 50 feet long by 23 feet high by 2 feet thick. It started at the bottom, as shown by the

* Read March 7th, 1894, before the American Society of Civil Engineers.

position in which it lay, actually tearing out the rock which was still clinging to the brickwork at the bottom.

The old race wall was very defective and was replaced with a new wall, the whole length of the front of the property being 103 feet 6 inches. As the water in the race could not be let out excepting on Sundays between the hours of 8 a.m. and 5 p.m., it was necessary to put in a coffer-dam while the wall was built and the head gates put in place. All the material was made ready for a speedy placing in position of the dam, and on Sunday, May 28th, it was successfully accomplished in the allotted time. The bottom of the race was rock, rather irregular on top, and the use of flour sacks partly filled with dry cement mortar was resorted to, in order to fill the gaps under the sheet piling, a layer of bags being placed at the bottom and tamped down so as to pack closely. The cement absorbed the water and set as a solid stone, filling every crevice, the interior being filled with 18 inches of clay puddle, also rammed down. In order to prevent the dam from slipping on the rock, holes were drilled in the rock about 6 feet apart along the line of the race wall, and 1½ inch

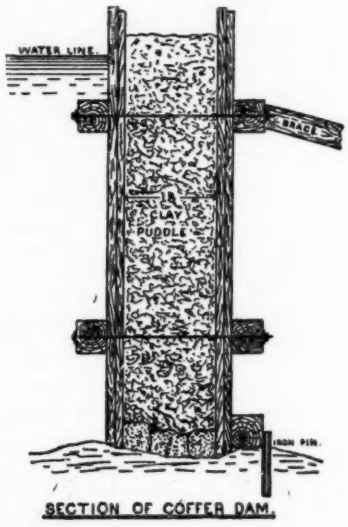


Fig. 4.

round iron pins dropped into them. A hemlock stringer 6 × 6 inches was laid against them on the rock and the first course of sheet piling nailed to it. The girts above were 6 × 6 inches, and were stayed with ⅝ inch bolts and cast-iron washers, to prevent the puddle from spreading the dam. The first course of sheet piling on each side was 1½ inches

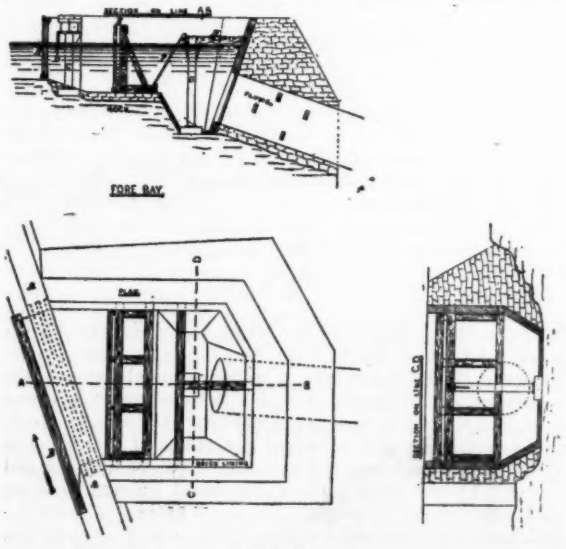


Fig. 5.

thick, and another course of 1 inch was fastened over, to batten the joint. Fig. 4 shows a section of the coffer-dam.

The old race wall was removed in sections and replaced by the new wall; the rock was removed and part of the fore bay with the head gates in position was built, and water was turned in against the gates by July 18th, although the coffer-dam was not removed until August 14th. Fig. 5 shows arrangements of head gates, fore bay, racks and flume. The arrow indicates the direction of the water as it flows in the race. A A, is the race wall with an opening in front of the fore bay, 21 feet wide, which is spanned by three 16 inch steel I beams, supported in the centre by an iron column, C. The opening is widened out on the inner face of the race wall to 26 feet, so as to give easier entry of water unto the fore bay. This opening is guarded by coarse rack, B, made of 1¼ inch round bars spaced 6 inches apart, and serving to stop any large pieces entering the forebay. On the face of the column, C, is a bracket supporting a wide plank, D, 2 inches thick, which has its lower edge 1 foot below the surface of the water. This keeps out much of the floating *débris* carried along with the water, such as shavings, straw, leaves, &c. The gates, E, are placed inside the wall, so that they are protected by the building to be erected. Temporarily they are now enclosed in a frame shanty. The fine rack, F, is set at an angle of 60°, so that in clearing off the rack the débris is drawn and deposited on the platform, H. Cast-iron column, G, carries a 12 × 12-inch oak timber that holds the head of the fine rack, F. A No. 10 wrought-iron slush pipe, I, fig. 2, is carried along the top of the flume outside, terminating below the floor of the wheel pit, and is designed to carry the débris raked from the fine rack directly into the wheel pit. Fig. 6 shows head-gate construction in detail.

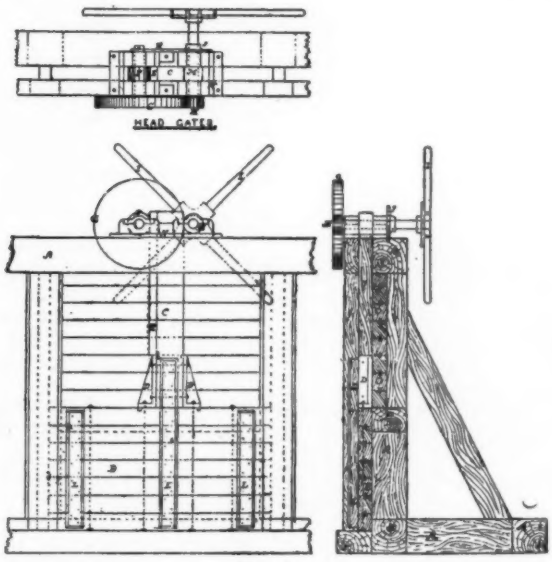


Fig. 6.

All the gate frame is made of 12 × 12-inch white oak, fitted with double mortise and tenons, and all bolted and put together at joints with red lead and oil. The gates, B, are made of seasoned white oak plank, 5 inches thick and 6 inches wide, with a ¾ × 1¼-inch tongue strip between the planks. These are all jointed with red lead and drawn together with 1-inch bolts and battens, L, secured by ⅝-inch lag screws. There are three gates, each covering a waterway 5 feet 4 inches × 2 feet 6 inches, all the water being admitted below girt, P. The space between the top frame and girt, P, is filled with the same material and form as the gates themselves. The rack staff, C, is 5 × 9 inches oak and fastened to gate, B, by the cast-iron brackets, D, all thoroughly bolted. On the side of rack staff, C, is fastened a straight rack, E, with the teeth boxed. The bed plate, N, contains the raising mechanism. The pinion, F, has 12 teeth, boxed, and is 2 inches pitch and 4 inches face, meshing into the teeth of rack, E. On the outer end of the shaft carrying pinion, F, is a spur wheel, G, having 55 teeth, 1¾ inches pitch, and 3½ inches face. Into this gears the pinion, H, having 12 teeth. The shaft operating the pinion, H, has on its other end a spider hub fitted with lever arms, I. A loose collar, M, plays on the shaft and acts as a roller against the back of the rack staff, C. A rachet wheel, J, is

keyed on this shaft and engages the pawl, K, which retains the gates at any height.

Fig. 7 shows details of fine rack construction. Sections 2 feet wide are made, so as to allow of easy removal, instead of making the rack all in one piece, as is usually done. The tie rods are ½ inch diameter, with countersunk head let into the first bar of a section. The thimbles are made of ½-inch wrought-iron pipe. Alternately the thimbles and bars are slipped on the bolts, and, when screwed tight together, the ½-inch nut on the end maintains a like spacing. The bars are ¼ × 2 inches in section, and are turned edgewise to a 2-inch inner radius at the upper end, the better to land the rakings on the platform. The holes for rods are drilled ⅝-inch centres from the back of the bar, so as to allow the rake teeth to clean the rack.

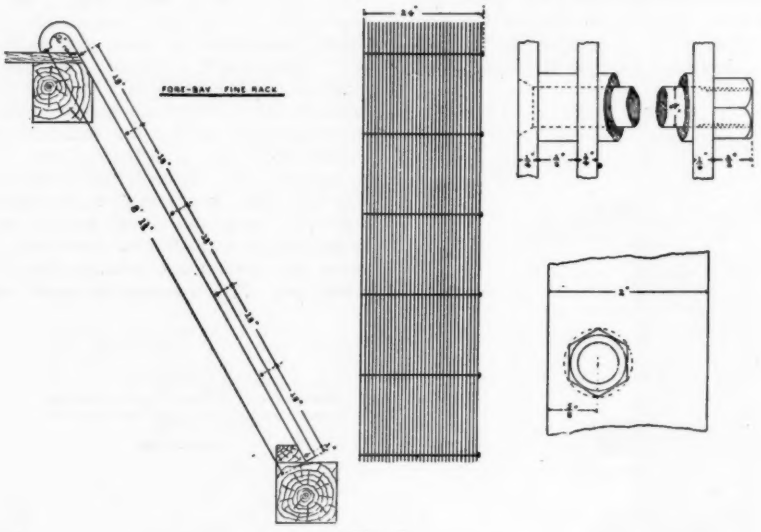


Fig. 7.

Fig. 8 shows the general arrangement of the engines and water wheels in the power-room. The room is 50 feet wide by 64 feet long; the wheel pit, as before stated, is 14 feet wide by 64 feet long, leaving the engine floor 36 feet wide, giving space enough to place four horizontal engines of 500 H.P. each.

The water-wheels are twin Poole-Leffel central-discharge turbines, 23 inches in diameter, and at a speed of

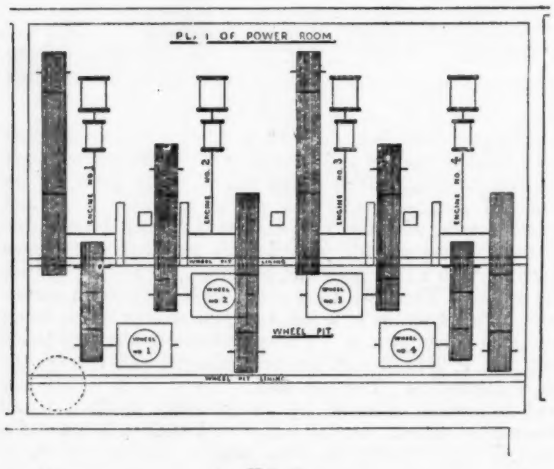


Fig. 8.

560 revolutions per minute, under a head of 92 feet 6 inches, develop 500 H.P. each, with a discharge of 3,800 cubic feet of water per minute. The wheels proper are made of phosphor bronze with buckets of Otis steel, tinned. The wheel bed-plates are heavy cast-iron box sections, machined and bolted together with heavy bolts fitting reamed holes. The wheel shaft is 4⅞ inches diameter, running in adjustable babbet-lined bearings. A rope wheel, 4 feet in diameter is keyed on the shaft, and is grooved for 15 1¼-inch Manilla "stevedore" ropes, made with four strands and a core, worked in with plumbago in the process of making. From the 4-feet wheel, 15 ropes run to a rope wheel on the line shaft above, 76·8 inches in diameter, and grooved for 16 1¼-inch ropes. The rope being endless, the idler strand is passed over a 5-feet single grooved wheel, placed in a movable frame. The frame traverses in iron guides and maintains by its weight a constant tension on all the ropes. This is made adjustable for the amount of tension, by the application of counter-weights to the frame. The speed of the line shafts is 350 revolutions per minute, and the rope travel is 7,037 feet per minute.

The water-wheels are supplied from a steel flume 7 feet in diameter, as shown on fig. 2. From the horizontal portion of the flume a 4-feet pipe leads down to each wheel and has a geared 48-inch Chapman valve at the lower end, between pipe and penstock, as shown on fig. 3. These valves are fitted with a 12-inch by-pass, for the purpose of equalising the pressure on both sides of the large valve, in opening or closing.

Fig. 9 shows the steel flume. From the fore bay to the

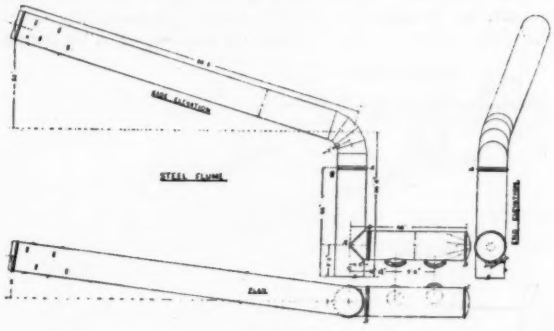


Fig 9.

flange, A, at the bottom of the elbow, the plates are $\frac{5}{16}$-inch thick. All below flange A are ⅜-inch thick. The $\frac{5}{16}$-inch portion is all single riveted. The longitudinal seams of the ⅜-inch portion are double riveted. Bottom head, B, is ½-inch thick and flanged to an internal radius of 1½ inches. Head, C, is ½-inch thick and convexed to a radius of 7 feet. The centre of this head is stayed to the second sheet from the end by eight 1¼-inch bolts. Bolts are spaced through head on an 18-inch circle. Flanges, A, D, D, are made of 3 × 3 × $\frac{7}{16}$-inch angles, and are held together by 132 bolts ¾ × 2½ inches. Joint packing was made of ½-inch solid round rubber. At the upper end of the flume, where it is built in the fore bay, an angle-iron ring of 4 × 4 × ½ inch is riveted outside and 18 inches from the end.

This is to form a stop water, as well as an anchor. Besides this, short pieces of 3 × 3 × $\frac{7}{16}$ inch angle are riveted on the outside, to securely anchor the pipe in the masonry. All the variations due to contraction and expansion is absorbed at the elbow. At the junction of the horizontal and vertical portions of the flume two 1½-inch stay bolts, E, with nuts and packing on the inside and outside, run through the pipe. These are designed to prevent any dilation or distortion at that point. The flume at bottom head, B, rests upon steel I-beams, and upon the rock. The flume complete weighed some 31 tons. All was coated with two coats asphalt paint, inside and out.

(To be concluded.)

TESTS OF A SMALL ELECTRIC RAILWAY PLANT.*

By JESSE M. SMITH.

This paper is designed to give in a concise form the results of a test made in October, 1893, on the power plant of the Wyandotte and Detroit River R. R., which is a suburban road running from Detroit to Trenton, Michigan, 10·5 miles long.

The plant contains two tandem compound condensing engines rated at 150 H.P. each, and guaranteed for a maximum load of 225 H.P., made by the Phœnix Ironworks Company, Meadville, Pa. Each engine is belted direct to a Westinghouse railway generator of 150 E.H.P. The vacuum is obtained by a Conover air pump and condenser belted directly to the engine shaft. The boiler feed pump is driven from the air pump shaft. Steam is supplied by two Manning vertical boilers. One engine and dynamo only were used during the test. It will be noted at the outset that each engine and dynamo is designed to deliver an average of 150 H.P., but that during the test the average load on the engine was only 70 I.H.P., and the maximum 141 I.H.P. The best conditions of economy were therefore not realised. The test was made under commercial conditions for the owners of the plant. All the machinery had been run about three months, and no adjustments by the makers had been made since it was first put in. No special care had been taken to get very close regulation either of the engine or generator. One boiler was fired with coal, and used exclusively to supply steam for the fuel atomiser of the other boiler. "Straight crude oil" was used exclusively as fuel for the boiler, which supplied steam to the engine, and no steam was used from that boiler for other purposes. Indicator cards were taken at intervals of 5 minutes during the 17½ hours of the test. A Tabor indicator was applied directly to each end of each cylinder, and all operated by the same mechanism. Indicator cards were taken simultaneously from the four indicators by two persons on a signal given at the proper time, without regard to the load on the engine. The speed of the engine was determined by a continuous revolution counter which was directly connected to the shaft of the engine. The variation of speed was shown by a tachometer belted directly to the engine shaft, and constantly in service. It was carefully compared with the revolution counter when on constant speed, and was made to agree with the counter. The speed of the dynamo was taken at four different times by a revolution counter held in the end of the shaft for five consecutive minutes each time. Three readings gave 604 revolutions, and one reading gave 603 revolutions per minute. The speed of the air pump was taken in the same way.

The steam gauges on the boilers were compared to a standard gauge from the University of Michigan, and found to be correct. These gauges are connected to the boiler near the bottom, so that they show the pressure due to a head of water of about 10 feet in addition to the steam pressure. The boiler gauges, therefore, show about 5 lbs. more pressure than the pressure of the steam in the boiler. The standard gauge, when placed on the steam pipe of the engine just above the throttle valve, showed about 5 lbs. less pressure than the boiler gauge, so that there was practically no loss of steam pressure between the boiler and engine. The vacuum gauge was compared with a standard gauge from the University of Michigan, and showed a vacuum 1·5 inches higher than the standard. All the data given below have been properly corrected to agree with the standard instruments. The temperatures were taken by standard thermometers from the University of Michigan.

The ampères were measured by a Weston standard ammeter connected in series with the station ammeter. The volts were measured by a Weston standard voltmeter connected to the bus bars of the switchboard. Volt and ampère readings were taken every 10 seconds by a different person at each instrument, the time being given by a third person.

The water used by the boilers was taken from the overflow of the air pump, and weighed in two barrels on two scales, and was pumped from the barrels by the regular feed pump worked from the shaft of the air pump. The feed water passed through a closed heater with brass tubes, the heater being connected with the exhaust pipe between the engine and condenser. The fuel oil was stored and fed by the Snell water pressure system. The amount of fuel oil fed to the atomiser was measured by measuring the number of gallons of water which flowed into the storage tank.

The test proceeded continuously without mishap of any importance, and I was greatly assisted by Messrs. Weber, Becker, Bird, Clark, Ames, and Hamper, engineering students from the University of Michigan, and also by H. E. Whitaker, junior member of the society, who also worked up the indicator cards, and made the calculations of results.

The dimensions of the plant and data, and the results, are given in the following tables:—

DESCRIPTION OF PLANT.

Boilers.

Kind	Manning vertical tubular.
Number	2
Size	Known as 61-inch.
Rated capacity	150 H.P.
Inside diameter of fire-box	6 feet.
Height above grate	3 feet 6 inches.
Number of tubes	184.
Outside diameter of tubes	2½ inches.
Total length of tubes	14 feet 10 inches.
Length of tubes below water-line	10 feet 7 inches.
Heating surface in fire-box	89·2 square feet.
Heating surface in tubes below water-line	1,272·7 square feet.
Heating surface in tubes above water line	511·1 square feet.

Engine.

Kind	Phœnix Iron Works Co. Tandem compound condensing.
Diameter of high-pressure cylinder	11$\frac{1}{16}$ inches.
Diameter of low-pressure cylinder	20$\frac{1}{32}$ "
Stroke of piston	15 "
Piston valves on both cylinders both controlled by shaft governor.	
Number of fly-wheels	2
Diameter of fly-wheels	78$\frac{3}{8}$ inches.
Face of fly-wheels	16$\frac{3}{8}$ "
Weight of rim of each fly-wheel	2,445 lbs.

Air-Pump.

Kind	Conover belted to engine.
Size	No. 7.
Diameter of piston	15 inches.
Stroke of piston	7 "
Revolutions per minute	67.

Boiler Feed-Pump.

Kind	Single acting plunger driven from shaft air-pump.
Diameter of plunger	3 inches.
Stroke	6 "

Dynamo.

Kind	Westinghouse 4-pole railway generator.
Size	No. 1.
Rated capacity	111·9 kilowatts.
Rated capacity	150 E.H.P.
Standard speed	625 rev. per min.
Speed when tested	604 " "

Cars.

Maker	Jones.
Length	16 feet.
Weight	14,500 lbs.
Number of seats	22.
Kind of motors	Westinghouse.
Number of motors	2.
Rated power of each motor	30 E.H.P.
Number of cars in use	3.

Road.

Length	10·5 miles.
Kind of rail	T.
Weight of rail per yard	52 and 56 lbs.
Supported on cross ties.	
Ties covered with sand and resting on sand, except from Wyandotte to Trenton, which is stone ballasted.	

* Abstract of a paper to be presented at the Montreal meeting, June, 1894, of the American Society of Mechanical Engineers.

Speed of Engine as Controlled by Governor.

Revolution per minute by *revolution counter*, average for 8 minutes with dynamo belt off ...	238 revolutions.
Same, with dynamo running with brushes on, but main circuit open, average of 6 minutes ...	238 "
Average revolutions per minute on regular work during 362 minutes	234·3 "
Percentage of variation of revolutions	1·58 per cent.
Maximum revolutions per minute, as shown by *tachometer*, dynamo producing 0 ampères, engine developing 14·3 I.H.P.	239 revolutions.
Minimum revolutions per minute, dynamo producing 180 ampères, engine developing 165 I.H.P.	227 revolutions.
Maximum revolutions, as shown by *tachometer* during *regular run*	237 revolutions.
Minimum revolutions, as shown by *tachometer* during *regular run*	233 revolutions.
Average revolutions, as shown by *tachometer* during *regular run*	234·5 revolutions.
Total variation	4 revolutions.
Percentage of total variation	1·7 per cent.

Distribution of Power Used.

Power consumed by friction of engine, air-pump, and boiler feed-pump, with main belt off ...	9·22 I.H.P.
Friction of engine, air and feed-pumps, and dynamo, with brushes off	11·34 I.H.P.
Friction of dynamo and belt	2·12 I.H.P.
Power consumed by engine, air and feed-pumps, and dynamo, with brushes on and main circuit open	14·34 I.H.P.
Power required to charge fields of dynamo ...	3·00 I.H.P.
Rated capacity of engine	150 I.H.P.
Rated capacity of dynamo	150 E.H.P.
Percentage of engine capacity required by friction of engine, air, and feed pumps $\frac{9{\cdot}22}{150}$ =	6·15 per cent.
Maximum power developed by engine, as shown by indicator cards, during economy test ...	141·4 I.H.P.
Minimum power developed by engine, as shown by indicator cards, during economy test ...	21·27 I.H.P.
Average power developed by engine, as shown by 208 sets of indicator cards, during economy test	70·1 I.H.P.
Maximum volts developed by dynamo	520 volts.
Minimum " " "	480 volts.
Average " " "	501 volts.
Maximum ampères developed by dynamo ...	200 ampères.
Minimum " " " ...	4·7 ampères.
Average " " " ...	67 ampères.
Average watts delivered by dynamo	33,567 watts.
Average electrical horse-power delivered by dynamo	45 E.H.P.
Average indicated horse-power delivered to pulley of dynamo, estimating friction of armature shaft, to be the same as friction of belt ...	59·8 I.H.P.
Average commercial efficiency of dynamo $\frac{45}{59{\cdot}8}$ =	75·25 per cent.
Average number of cars in use during test ...	2·89 cars.
Number of passengers on cars during 17⅓ hours	1,014
Number of single trips of cars	64
Average number of passengers on cars per single trip	15·2
Average number of passengers on cars at any one time (estimated)	8
Weight of 10 persons at 140 lbs. each	1,400 lbs.
Weight of cars	14,500 lbs.
Total weight of cars and persons ...	15,900 lbs.
Average weight in motion	45,950 lbs.
Average electrical horse-power per 1,000 lbs. of weight moved	0·98 E.H.P.
Average horse-power developed by engine per 1,000 lbs. of weight moved	1·52 I.H.P.
Average watts required per car	11,615 watts.
Average electrical horse-power per car	15·54 E.H.P.
Average horse-power developed in engine per car	24·25 I.H.P.
Average watts delivered by dynamo per horse-power developed in engine	478·8 watts.
Average watts delivered by dynamo per horse-power delivered to belt of dynamo	557·3 watts.

Rate of Speed of Cars.

Length of road	10·5 miles.
Time of round trip, including 2 minutes stop at each end and at 16 railroad crossings	90 minutes.
Average speed per hour, including all stops, 21 miles in 1·5 hours...	14 miles per hour.
Running time, allowing two minutes at each end 4	
1¼ minutes at each railroad crossing ... 4	
90 − 8 =	82 minutes.
Average speed between stops = 21 miles in $\frac{82}{60}$ = 1·366 hours ... ... =	15·38 miles per hour.

Mileage of Cars.

Two cars, 11½ round trips each	23 miles.
One car, 10½ " "	10½ miles.
Total number round trips	33½ miles.
Total car miles—33½ × 21...	703·5 miles.
Average miles run by each car	234·5 miles.

Time of Service of Cars.

Two cars, 11 round trips, 1·5 hours each... ...	33 hours.
One car, 10 round trips, 1·5 hours each	15 hours.
Car hours	48 hours.
Time required by each car to get to end of road to commence its trip and get back to power house	¾ hour.
Total time of cars away from power house—	
2 cars, 16·5 + 0·75	34·50
1 car, 15 + 0·75	15·75
Total car hours	50·25
Time of test	17·33 hours.
Average number of cars in use during test $\frac{50{\cdot}25}{17{\cdot}33}$	2·89

Economy Test.

Duration of test	17⅓ hours.
Average horse-power developed in engine as shown by 208 sets of indicator cards taken at 5 minute intervals	70·1 I.H.P.
Average horse-power delivered by dynamo as shown by 6,209 sets of readings taken at 10 second intervals	45 E.H.P.
Net average steam pressure in boiler by half-hour readings	111·8 lbs.
Average vacuum by half-hour readings	25·2 inches.
Steam used by engine in 17⅓ hours	29,829·6 lbs.
Steam used by engine per hour	1,721·1 "
Steam used by engine per horse-power per hour	24·55 "
Steam used by fuel oil jet in 17⅓ hours	5,064·5 "
Steam used by fuel oil jet per hour	291·5 "
Steam used by engine and fuel oil jet per hour...	2,008·8 "
Percentage of steam used by fuel oil jet... ...	14·5 per cent.
Weight of oil per gallon at 61° Fahr.	6·57 lbs.
Fuel oil used to raise steam pressure before starting, 5 gallons	32·9 "
Fuel oil used for engine during test of 17⅓ hours, 251·7 gallons	2,308·3 "
Fuel oil used per hour for engine, 20·25 gallons...	133 "
Fuel oil used per horse-power per hour for engine, 0·29 gallon...	1·9 "
Additional fuel oil which would be required to maintain oil jet for 17⅓ hours, 59·71 gallons ...	393·3 "
Additional fuel oil which would be required to maintain oil jet for one hour, 3·43 gallons ...	22·58 "
Total fuel oil that would be required during day, 416·4 gallons	2,734·5 "
Average temperature of water flowing from air pump	91·8° Fahr.
Average temperature of feed-water entering boiler	126·6° Fahr.
Rise of temperature of feed-water due to heater	34·8° Fahr.
Percentage of fuel saved by heater	3·06 per cent.
Fuel oil required to evaporate 1,000 lbs. of water from 126·6° Fahr. into steam at 112 lbs. pressure	11·79 gallons.
Water evaporated from 126·6° Fahr. into steam at 112 lbs. pressure per gallon of fuel oil ...	84·81 lbs.
Ditto per pound of oil	12·9 "
Kind of fuel oil used	Straight Ohio crude.
Kind of fuel oil atomiser	Snell.
Area of steam outlet of atomiser...	0·07 sq. inch.
Which is same as a round hole 0·3 inch diameter.	

It will be noted that 14·5 per cent. of the total steam generated was used by the fuel oil atomiser. The atomiser was not properly proportioned for the work, and did not receive enough air. The flame was red and evidently not economical. The atomiser and furnace have since been rearranged with much better results.

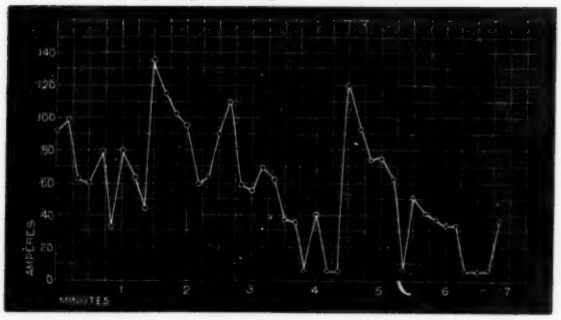
In this engine the piston valves which distribute the steam to both high and low pressure cylinders are controlled by the governor.

While this is a condensing engine, the high pressure cylinder does a good share of the work even on the lightest loads, and the receiver pressure does not vary greatly either during a single revolution or during a change of load of from 21 to 101·8 horse-power. While the load changes 485 per cent., the average receiver pressure only changes 167 per cent., and even when the engine ran with the belt off and developed 9·2 horse-power, there was no negative work in either end of either cylinder. These results, which I believe to be highly important, both for economy and close regulation, are due to the valves of both cylinders being controlled by the governor.

The variations in load in a plant of this kind are not only extreme, but rapid.

The curve shows a sample of the ampère readings during about 7 minutes, at intervals of 10 seconds.

Sample ampère readings at 10 second intervals.



The variation is from 5 to 134 ampères, and in one interval of 10 seconds the load increased 115 ampéres, which equals 120 indicated horse-power.

During the regular operation of the plant, and with these extreme variations in load, the needle of the tachometer never left the space enclosed by the 230 and 240 revolution marks.

CORRESPONDENCE.

The Economy of Electric Light Engines.

I had not the pleasure and advantage of being present at the last night of the discussion upon Mr. Crompton's paper upon "The Cost of Electrical Energy," when Prof. Unwin spoke, and, as I learn from the very full report in the Electrical Review, objected to Mr. Crompton's view, that to obtain the best results a high-speed engine should be used. Prof. Unwin did not, as I understand, object to the high-speed engine, but he considered that the reduction of cylinder condensation obtained by its high rotative speed (not high piston speed; that has no such effect), could be equally well obtained in other ways, and therefore (so I judge from the report) he treated the question of high or low speed as an open one. He added that I had "fairly and frankly said at the last meeting that up to the present it was the long-stroke slow-speed engines which had given the highest economical results, and that required to be borne in mind along with the statements about the necessity for high speed and short stroke."

Those who have at once the sad privilege and the heavy task of carrying on the work of the late Mr. Willans—work which cannot be carried on by standing still, and in which a halt is a retreat—would be false to their best traditions if they did not heartily recognise the advances of all workers in the same field. But though I desired to speak with hearty appreciation of the splendid, and probably unique, results obtained by Messrs. Sulzer, I also wished to make clear, and supposed that I had made clear, my emphatic belief that to the high-speed, short-stroke engine, and not to the slow-speed long-stroke engine belongs the future of electric lighting. For the Sulzer engine a consumption of under 12 lbs. per I.H.P. per hour of steam is claimed. That Messrs. Sulzer publish the figures is enough evidence for me, but as yet we are entitled to look upon them as exceptional. The Willans engine has scored within a pound of the same figures, under circumstances, so far as I know, not more exceptional; in fact, 12·8 lbs. was reached by the first Willans engine ever designed specially for condensing. I said, and believe, that the high-speed single-acting engine can be brought to the same figures per I.H.P. as the Sulzer engine, though, in the interests of the best result per *brake* H.P. (which is much more important to the user), it might be unwise to go very far in this direction. And I wish to point out now that even if the friction loss of the slow speed engine be treated as only the same as that of the Willans engine (which I do not admit), and a superiority of one pound of steam per I.H.P. be conceded to the former, even then the moderate allowance of 7 per cent. for loss in belt or rope transmission will bring the steam consumption of the two engines exactly on a level at the spindle of the dynamo, and consequently the steam consumption per *electrical* horse-power will be identical, while the disadvantages of a larger and costlier engine, and the complication and indirect costliness of belts or ropes, will remain. It may be said that belts or ropes will not be used; that the user will face the huge first cost (and the increased bearing friction) of a dynamo large enough for direct-coupling to the large and costly slow-speed engine, and that the pound of steam will turn the balance after all. I do not believe it, but neither do I admit the pound of steam as a permanent factor in the question. It is but an incident of the present state of the competition between the two systems, between an old and accepted system based upon the experience of years, and a new system whose advocates have only realised comparatively lately that the highest economical results are within their reach. There is nothing in "slow-speed and long-stroke" to give it an economical advantage over "high-speed and short-stroke," but the reverse, and when the call arises for high-speed engines of the same consumption per I.H.P. as those quoted by Mr. Crompton, the narrow margin between the two classes will more or less completely disappear, even if it be not reversed. It should also be remembered that to a certain extent the controversy is in the clouds. The dynamo is not driven by "I.H.P.," but by "B.H.P.," and no one can say that whatever the difference in favour of one or two exceptionally good low-speed engines may be, per I.H.P., there is anything like the same difference per B.H.P. The indicator is a splendid instrument of research for the engineer, but it does not give quite the information required by the user; some day the only consumption trials which will command attention will be those made upon the brake. Others who are better qualified may support the other elements of Mr. Crompton's impugned "formula"; my task is only to maintain that the high-speed engine is rightly included in it, or at least to avoid being quoted on the other side.

Mark Robinson.

Electrical Efficiency.

I have been much pleased as a user of electricity to notice your treatment of this question. I know I have been, ever since its introduction for lighting and transmission, supposed to be bitterly opposed to it, the fact being I was simply asking for results thoroughly reliable. With Prof. Kennedy's address and your article, p. 631 of June 1st issue, I entirely agree. So far from being prejudiced, I may point to the fact that since I started a couple of electrical drills two years ago I have purposely avoided testing the efficiency of the plant; because I knew the conditions were not such as would give a fair result, the engine and dynamo being too powerful for the work we are yet doing.

Our specification required that the motor on each drill should afford 6 B.H.P., this I did test, and having got it I went no further.

I may say to their credit that last week they produced in each shift of eight hours—No. 1, 80 holes, giving 138·76 tons; No. 2, 74 holes, 144·46 tons—of ironstone.

I shall have four more working very shortly at another mine—and at this latter place we have already lighted the main roads with incandescent lamps.

Now, having said so much, I shall not be misunderstood if I say anything which may seem detrimental to its value.

I am not prepared, and I doubt whether I ever shall be, to take electricity into a dry and dusty coal pit, the risks of fire I think are too great, and the results if a fire did begin, too terrible to contemplate. It is 30 years ago this summer since I helped all-night to battle with a fire in a colliery shaft, beyond which 50 men and lads were shut in, and 17 were eventually lost.

As you no doubt know, the wires pass through long distances if used in a mine where no one sees them perhaps for many hours, and a fire would have the opportunity of getting a firm hold in a place where, from the strong current of air, it would burn fiercely, and no water near. Timber and coal would afford a conflagration which would never be extinguished until the mine was drowned—the ironstone won't burn, and so I think we may safely use it.

Now as to efficiency, we have been told *ad nauseam*, that

in using compressed air we get only 30 per cent. and even 25—(and in many cases I don't dispute its accuracy), whilst from electricity we shall have 75 or 80—but what is the truth, air compression requires just as much brains as electricity, but it does not get it. Any fitter who can put an engine together is thought good enough to have entire charge of putting down an air plant. The Birmingham fiasco I consider quite a disgrace, because I am sure from the report issued previous to commencing that the laws applying to it were known, and while compressed air never, or hardly ever gets fair play, electrical, or what is called "commercial efficiency," is put in contrast with the actual or mechanical efficiency of the air plant.

When we speak of the efficiency of air, hydraulic power, or ropes, we compare, say the foot-pounds in water lifted by a pump, with the I.H.P. of the engine, which is a totally different test from the C.E. of the electricity, and grossly unfair.

If we are pumping with a high-speed centrifugal pump and can put a motor on the spindle of it, then I am quite prepared to expect a higher efficiency than with any other system of transmission; but we have to take things as we find them, and this class of quick running machine can very seldom be used. Instead of it, a very slow moving pump compels the gearing down of the speed until very great loss accrues—just as Prof. Kennedy puts the efficiency at 39—so I have always looked on 40 per cent. as what we may expect from a slow moving mine pump.

I quote in confirmation of this the very careful tests of an electric pump at Seghill Colliery by Mr. C. C. Leach, Vol. iv., of the *Transactions of the Federated Inst. of Mining Engineers*. There the water was measured, and observations taken every tenth minute for an hour. Water, 90·08 gallons; head, 95 feet; suction, 24 feet when running—and the useful effect, 32·25 per cent.—this bad result I should suppose may be attributed first to the gearing down from 1,180 of the motor to 47·43 of the pump. The engine, a Robey vertical, 9½ inches diameter × 9 inches stroke, does not seem much too big for its work, but it is another proof of what you say "That the truth is often unpalatable, but when it is ignored by engineers, very serious consequences may arise."

A. L. Steavenson, M.Inst.C.E.

May 2nd, 1894.

Electricity Meters.

Mr. Wilson's veracity does not seem to improve, but I may be permitted to point out, before this correspondence closes, that the use of a transformer in connection with a low pressure voltmeter for measuring high pressure electricity is due to me, and was published for the first time in the Electrical Review, as previously quoted by me, and it is public property from that date only.

Prof. Thomson may well cry out, "Save me from my friends," when they attempt, like Mr. Wilson, to claim for him as an invention the adaptation of a well known method to a well known appliance, for a purpose to which it had been previously applied by others. Mr. Wilson had better leave the question of priority in inventions alone in his papers, unless he is prepared to substantiate his claims by clear proofs.

Rankin Kennedy.

Electric Traction.

As one who ventured to "air my views" on Prof. Kennedy's address to the Mechanical Engineers, I have read with some interest your article on "Electric Traction," and I venture to suggest that you have fallen into the same error as Prof. Kennedy in damning the overhead system of electric traction on account of its low efficiency, without taking into consideration its many advantages.

As I then stated, I have no intention of quarrelling with Prof. Kennedy's 35 per cent. of efficiency, and I do not want to produce any higher efficiency to prove the many merits of electric traction.

I cannot help thinking that the information as regards electric traction obtained from America has not received a very careful digest on your part, as I am quite sure if it had your remarks on American experience would be very different to what you have stated. To prove your point, you quote a report from the Railroad Commissioners of Massachusetts, which has received a good deal of prominence, but which, on careful consideration, has very little value as a criticism on electric traction; and if you look into the systems to which this report refers, you will find that the whole of the disadvantages which are put forward as an argument against the adoption of electric traction are misplaced, and are attributable to the fatal effect of over-capitalisation.

I have lately had occasion to go very carefully into these American statistics, and on the basis of Prof. Kennedy's own figure of efficiency, I find all those lines referred to by the Commissioners of Massachusetts would now be very profitable, and far better paying properties than they ever were before with horse traction, if only they had been equipped at a reasonable price.

You say there is no data in England on any sufficient scale for you to arrive at any idea as to the cost of electric traction, and that therefore it is necessary to go into American experience. I venture to think that you will alter your opinion somewhat if you will take the present South Staffordshire figures of working, and compare them with the cost of working when steam was employed; also the figures of working on the Liverpool Overhead Railway, and compare them with any railway of a similar class; also the working of the Leeds Tramways, and the wonderful results obtained on the Blackpool system some two or three years back; and I am desirous of challenging you to produce any single form of traction working in this or any other country, which can compare with these results.

The criticisms raised against Prof. Kennedy's address were entirely due to the position he took up. He condemned electric traction on account of its low efficiency, and placed it beside that of steam with 85 per cent. of efficiency. This efficiency has never yet been obtained on any tramway engine working in this country, or anything like it. Hence the argument was fallacious. He objected to the introduction of overhead traction because he was so conservative that he was bound to look at its disadvantages without considering its many advantages, while the traction interests are of opinion, and I think very properly too, that the persons who are to decide whether overhead traction shall or shall not be adopted, are the authorities of the towns who have to consider the question, and not any interested party who may have a particular form of pet motor of their own to put forward.

If the gas motor, compressed air, or any other system of mechanical motors is better than that of electricity, by all means let us have it. I am perfectly disinterested myself, and I am just as ready to acknowledge the advantages of any system over others if they exist; but it appears to me exceedingly puerile to criticise a system of which there are now some 7,000 miles working in America, several hundred miles on the Continent, and also some examples in England, by comparison with other methods, which, for all practical utility, are at the present moment merely imaginations in the minds of some few inventors.

If I were desirous of criticising your article at length, I might ask you to tell us how three or four horses could draw a car in America at the same speed as the electric car.

It is satisfactory to me, however, to observe that after having stated that you generally agreed with the remarks of Prof. Kennedy, and not with the remarks of those who criticised his address, you conclude by saying that after all electric traction is so convenient, smooth, clean and noiseless, that despite the low efficiency and the other minor difficulties, it has made more progress than any other form of mechanical traction, and you are positively certain the efficiency will be largely improved. As that is the main point of my contention, I am quite satisfied to leave the argument here.

Stephen Sellon.

I have glanced through your article on "Electric Traction" in this week's issue. I think the whole question of efficiency after all resolves itself into one of £ s. d., and from this standpoint your article can only be classed as simple nonsense, because electric traction is worked upon these lines 3d. per mile cheaper than was steam, and more than 3d. per mile cheaper than steam is being worked upon the Birming-

ham and Midland, the Dudley and Stourbridge, and the Birmingham Central Tramways, all of which lines it runs in connection with, and it is actually working cheaper than cable. Your article speaks of facts.

The facts I now give you are the only facts that can be given as to the comparative costs of electric, cable, and steam traction in this country, and they altogether disprove the assertion in your article.

A. Dickinson.

June 2nd, 1894.

A Loud-Speaking Telephone.

I notice in your issue of June 1st a letter from the General Electric Company, in which they state my apparatus is a copy of theirs.

This I deny absolutely, as I have never seen the internal construction of the receiver they refer to, nor have I seen or ever heard a description of it.

Alfred Graham.

Regulation and Governing of Electro-Motors.

I note your editorial as to my method of control in your issue of April 27th, also the letter from "The Writer of the Article" on "The Heilmann Locomotive." The latter now says: "Of course, all turbines are not analogous to a dynamo, but some are, such as the inward flow type." You, in your editorial, say: "The inward flow, vortex type turbine, invented by Prof. James Thomson, is the best example of a turbine acting exactly as an electro-dynamic machine."

Had the writer of the original article limited himself in this way to an especial type of turbine, my comments would not have been made.

In closing your editorial of April 27th, you say: "To apply this new scheme (my system) to the Heilmann locomotive it would only be necessary to add another dynamo to act as a variable pressure generator between the steam-driven dynamo and the motors." I call your attention to the fact that no new dynamo of any kind would be needed to apply my system to the Heilmann locomotive, but merely a change of circuit connections.

In your issue of May 4th, Mr. W. S. Boult presents an arrangement of apparatus as an improvement on my system. The modification covered by Mr. Boult's suggestion was invented by me over two years ago, but, as I believe, in an improved manner. Mr. Boult's suggestion to automatically weaken the one field as he strengthens the other, and *vice versâ*, is not practical. The field of B should be fully excited all the time. A should have an entirely separate field, which should be not only variable, but also reversible to secure the best results.

In the same issue, Mr. Sayers says that by his patented winding he can solve the problem of operating a generator without sparking with $\frac{1}{10}$th its normal field, the speed and current being normal. Any ordinary generator will do this without Mr. Sayers's patented winding, and at least a dozen different kinds are doing it daily in this country in connection with my system of regulation. Whatever virtue there may be in Mr. Sayers's winding, it is not needed to prevent sparking under the conditions named, for there is no sparking to prevent.

H. Ward Leonard.

May 25th, 1894.

Muirhead v. Commercial Cable Company.

Truth is said to lie (perhaps I had better use the unambiguous word "reside") at the bottom of a deep well, and there are some who suppose that therefore its application is to be confined to the small solid angle subtended by the mouth of that same well.

Mr. A. H. Dykes has evidently never seen a cable worked, or he would have known that recorder signals, under the conditions stated, should have been utterly unreadable, and in the form of very sharp V's, with any amount of superadded "wildness."

The rounded form of signal pictured in his communication is due to the shunt across the circuit, in which is introduced the battery, and theory is quite in accord with his results, which have, however, no bearing whatever on duplex working.

There is no need whatever for communications based on biassed experiments in any laboratory, as there are plenty of cables working duplex, where the result of any theory can be easily confirmed; and where all the results in question have been threshed out ages ago, as evidenced by Mr. Bailey's apposite letter.

The most amusing part of the whole business at the moment is to compare the special pleading of Dr. Hopkinson for the theorists, as contained in his "James Forrest" lecture, with the results arrived at in so many cases, where the result of theory alone is found to be utterly opposed to theory combined with practice, another confirmation of Mr. Preece's statement respecting the commercial value of theory uncombined with practice.

I should like to draw the attention of the professorial staff to the fact that it is after passing under their hands that students enter on practical work, and though a tree is not judged by its sapplings, which generally require a good deal of pruning and grafting, yet it is judged by its own fruit; and it therefore behoves them to see that the theoretical instruction does not act as a stumbling block to their subsequent career, and cause them to be left in the lurch by men who have entered on practical work through other channels.

F. J.

June 4th, 1894.

A Complaint.

Mr. George Kenyon's letter, which appears in your last issue under the above heading, is rather vague; surely he cannot wish us to believe for a moment that electrical engineers of any standing would appoint such incompetent men as those he describes. Of late years *electricians* (?) have sprung up mushroom fashion.

The real grievance at the present time is that no sooner does a man (who was previously known as an engine driver, wireman, fitter, or carpenter) take charge of a small electric light plant, than he dubs himself an *electrician*, and frequently obtains appointments for which he is not fitted, and this to the detriment of experienced and competent men. The trade is partly to blame for this, and the sooner a name is found for these would be electricians the better it will be for all concerned.

Electro.

Personal.

It is with much surprise that I notice in your issue of the 25th ult., under the head of "Personal," a repetition of the statement concerning my position in this company. After the official correction contained in the letter from the secretary, Mr. Latham, published in your number of May 18th, I consider comment is superfluous, but I must request you to give equal prominence to my statement, which is to the effect that I am the chief engineer and electrician of this company's station at Madrid, and that Mr. Drummond's position is that of *assistant* to me.

Should you require further evidence, a copy of my contract is at your disposal at the company's office in London.

John Wm. Chisholm,
(*Electricity Supply Company for Spain, Limited, Madrid.*)

I am instructed by my directors to write to you with respect to a paragraph headed "Personal" in your issue of May 25th.

Notwithstanding my letter of May 12th published by you, in which I stated that Mr. J. W. Chisholm was *chief electrician* of this company and Mr. Drummond *assistant electrician*, you now draw a supposed distinction between the engineering and electrical departments, and state your belief that Mr. Chisholm is head of the one and Mr. Drummond of the other.

Your statement is absolutely and entirely incorrect.

Mr. J. W. Chisholm is *chief engineer and electrician* of this company. Mr. R. H. Drummond is *assistant electrician*,

and is subordinate to Mr. Chisholm in every way.

Any authority Mr. Drummond may exercise over other members of the staff is derived from Mr. Chisholm.

My directors are surprised that after my letter of May 12th you should publish unauthorised and incorrect statements so detrimental to the position and authority of our chief electrician, and they request that you will be good enough to print this letter in your next issue.

P. A. Latham,
Secretary.

[We regret that through a misunderstanding Mr. Latham's former letter should not have been considered as conclusive; as a matter of fact, it was through inadvertence that we questioned the respective positions of the two gentlemen concerned. Now, however, the matter is set at rest, and we hope that Mr. Drummond will in future be more precise in giving information on matters in which he is concerned.—Eds. Elec. Rev.]

ELECTRICITY SUPPLY STATIONS.

Portsmouth Corporation Works.—No. 18.

In the series of articles on central stations which have appeared at different times in the Electrical Review, the gradual developments in generation and distribution have been shown; no system has, however, exhibited so many departures from recognised engineering practice as the Portsmouth Municipal Supply Works.

The progress which has been made in town lighting during the past few years has been gratifying, though objection might be fairly taken to the monotony of design, which has been a characteristic of many of the new electric light works. So stereotyped indeed, have many of these become, that to know the name of the system and the contractors was enough to enable one to give a fairly complete description. While repetition of machinery and apparatus has undoubted advantages, it rather precludes the possibility of great advances. It would not be fair to say that all stations are slavish copies of others. The most notorious cases of everlasting one standard pattern have been three-wire accumulator stations and house-to-house high tension systems. Possibly, without fundamental alterations, these systems had been improved to the utmost extent; as far as they went they were admirable, but without modifications they had achieved as much as one could reasonably have expected. Continuous current stations, with and without accumulators will, with skilful management, still show us something remarkable in the way of low costs, but the limit of achievement is clearly defined. It is to high pressure alternating with various transforming agents that we must look for future developments in generation and distribution. For adaptability to most cases the alternating current is incomparable, and this feature will be more clearly marked in the future.

The survival of the fittest goes on in England without much reference to outside development. It is indeed noteworthy how little American and Continental methods have affected English designs. A curious commentary on this is to be found in the case of the two or three electricity works designed on foreign plans which have proved to be distinct and unmitigated failures. It is difficult to advance any adequate reason for this. It is not on the score of prejudice that Americans and Germans have found England a closed market, nor is it by reason of inferior machines that foreign manufacturers have met with so little encouragement. If any satisfaction is to be derived from the fact, it may be emphatically and unhesitatingly stated that in electrical work, at least, Englishmen have loyally supported home industries.

The opening of the Portsmouth Station brings us to new methods of generation, and to the practical application of at least one theory which was thought to be still confined to the laboratory—we refer to the commutating of alternating into continuous currents. In saying this, we are not unmindful of what has been done by Hutin and Leblanc, Pollak, and others, but Mr. Ferranti can fairly claim the honour of being the first to use commutated currents in actual work.

Granted that what we may term the Portsmouth system involves a radical change from previous systems, the question naturally occurs to one: Is it an advance on the right lines? We must admit frankly that the Portsmouth station surmounts many of the difficulties, and meets some of the objections which one had felt were almost inherent in electric light systems. There may be small matters of arrangement which will not meet with universal approbation, but on the broad question of whether it constitutes a stage in the evolution of central station design, we think there can be no two opinions. At the same time, although there is a good deal of an experimental nature about the scheme, there is nothing that strikes one as being in the least degree risky. The mechanical engineer has never looked kindly upon the design of electrical machines. He has never got rid of the idea that there was a good deal of gingerbread and sealing-wax inside a dynamo, but the construction of the Portsmouth machines ought to appeal even to his mechanically constituted mind. In the battle of the systems, which we consider to be by no means over, alternating high tension system by this new development secures a strong position.

No doubt considerable fault will be found with the Portsmouth Corporation for embarking upon a scheme which in itself was experimental; but if municipalities do not strike out into new paths, we are in danger of becoming fossilised; furthermore, there is in this case no great risk, for the corporation possess consultants whose ability and caution are beyond question. Besides, it must be pointed out that Portsmouth, but for fortuitous circumstances, might have been saddled with a system of lighting which, though of itself sound, would have been in Portsmouth an absurdity. We must, however, leave this aspect of the subject, and speak for a moment concerning the history of electric lighting in Portsmouth; for like most other English towns, there is a history attached to its introduction into the town.

Portsmouth and the Introduction of Electric Lighting.

Not desiring to mince matters, we must declare that Portsmouth people, in the matter of electric lighting, have been decidedly difficult to move. Probably their state was no worse than the apathy of most towns; but it must be remembered that Portsmouth with its ramifications is one of the largest municipalities in the country. Besides its naval and military business it is a fashionable watering place; in fact, a more suitable place for electric lighting it would be extremely difficult to find. Curiously enough, in other matters the corporation have for years past carried on most extensive improvements, but on the subject of electric lighting they were by no means of one mind. But for the energy and perseverance of Mr. Alderman Ellis, the chairman of the electric light committee, who has gradually overcome the opposition of the town council, the electric lighting of Portsmouth might have been by this time in the possession of joint-stock enterprise.

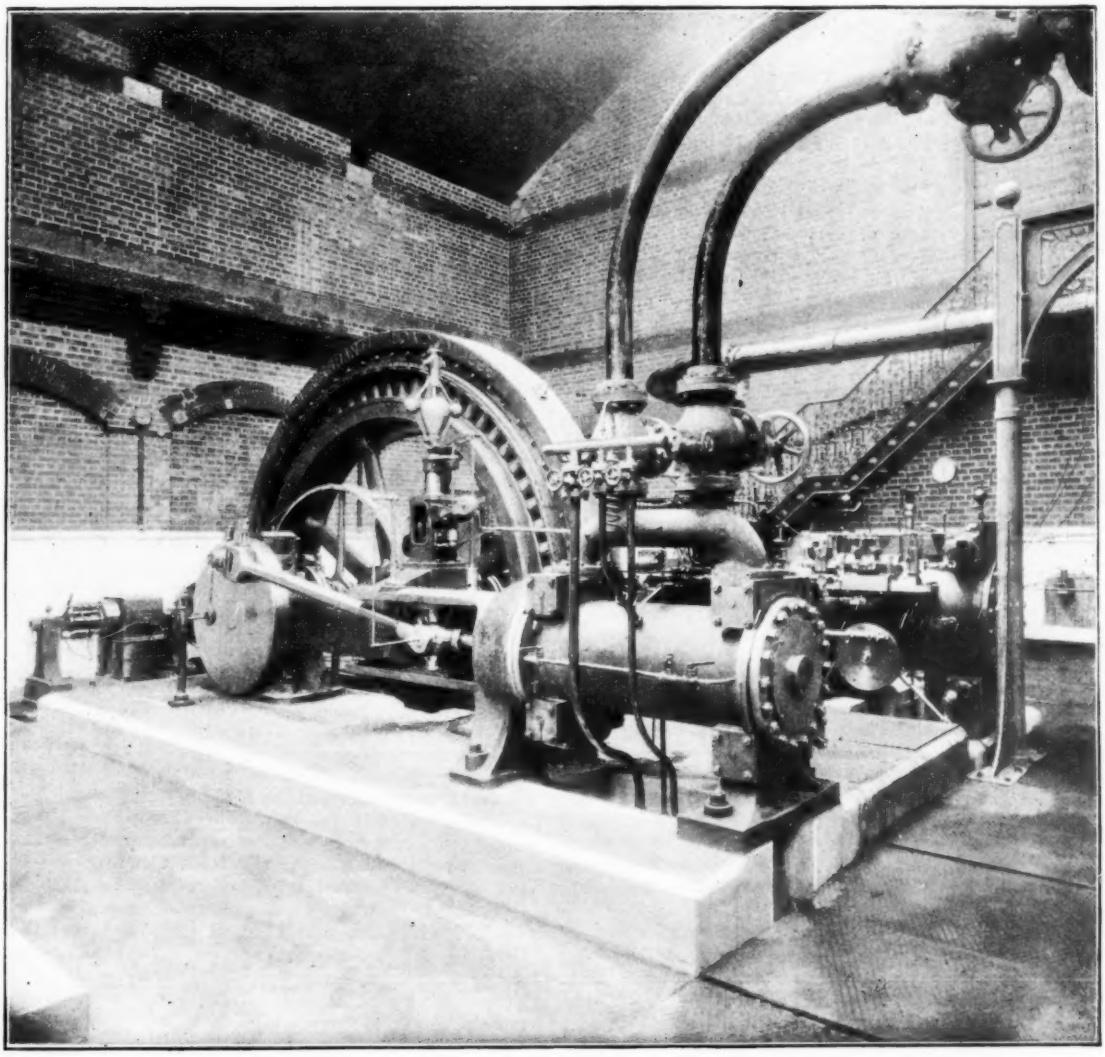
The date of first definite action was in the year 1890, when a provisional order was obtained; in the following year an electric lighting committee was appointed, with Mr. Alderman Ellis as chairman. Shortly afterwards the committee may be said to have passed through low tension fever; they had consulted an engineer who unhesitatingly recommended a low tension scheme. We do not propose to make much of this fact, except to say that the most distant points of Portsmouth are about five miles apart. Recovering, however, from the low tension state, and making further inquiries, they called in Dr. Garnett to report on the comparative merits of high and low tension. After due consideration of the matter, this gentleman decided that high tension was more suitable to the conditions of Portsmouth, and the town council, apparently satisfied with this advice, asked him to prepare estimates. Ultimately Dr. Garnett, in conjunction with Messrs. Waller and Manville, were appointed as engineers to carry out a scheme of high tension lighting.

About this time the corporation were hampered by the dilatory action of the Local Government Board in sanctioning the raising of a loan. Overcoming at last the *vis inertiæ* of this department, they wasted little time in proceeding with the scheme.

Most of the principal firms tendered for the erecting work, that of Messrs. Yates for boilers and engines, and that of Messrs. Ferranti, Limited, for alternators, being eventually accepted.

The system originally adopted was a plain alternating high tension, with rope-driven alternators, but an alternative scheme by Ferranti and Yates & Thom contained many distinctly novel suggestions, which were not without effect on the electric light committee. In this second scheme, Mr. Ferranti proposed a combined engine and alternator, without the intervention of ropes, and the use of commutated or rectified currents for the arc lighting. This scheme had a good deal to recommend it in the eyes of the council; it was a good deal lower in price than any other, and appeared at most striking characteristic. The station faces a small dock, remarkable as being the only land with a sea frontage owned by the corporation. Through this land pipes are laid which convey sea water to the station for condensing purposes.

On the ground floor of the buildings are arranged a boiler house, engine room, commutating room, coal store, and testing rooms. The floor over the boiler house is divided for offices and mess and committee rooms; these rooms are well furnished and elaborately decorated, perhaps the most noticeable one being the map room, where, in accordance with Board of Trade rules, the walls are carefully papered with a huge map of the district. The object of the map is to show the streets in which mains are laid. It is interesting, but, we should imagine, not quite as useful as



VIEW OF ENGINE-ALTERNATOR.

the same time to be a system which could be economically worked. After satisfying themselves that the suggestions were practical, they adopted Mr. Ferranti's plan, and became the pioneers of a system which in most of its features is novel, and, in all respects, is new to English practice.

THE WORKS.

The station is situate in Gun Wharf Road, the site being formerly occupied by a music hall, which some few years ago was burnt down. It is in a most favourable position both as regards the area of supply and the convenience of obtaining coal and condensing water. Here a large and commodious building has been erected close up to the roadway. There are no pretensions to style about the building, it being of plain red brick, solidity of construction being, perhaps, its

some of the models of districts which we have seen at other electric light stations. The engineer's room is on this floor, from whence the engineer on duty can command an uninterrupted view of the boiler house on the one side and the generating room on the other. Before passing on to speak of the machinery, we would mention the special arrangement which the chimney shaft has necessitated. Soon after excavations were commenced it was discovered that within a few feet of the surface a bed of shingle of considerable depth existed. Under these circumstances it was decided to build the chimney on a concrete raft. The raft consists of a bed of concrete nearly 20 feet square and 6 feet in thickness, which is bound together by steel joists. By adopting this method the weight of the chimney is evenly distributed, the

pressure transmitted to the shingle not exceeding 1 ton per square foot.

The length of the engine room is 102 feet, the breadth being 66 feet. This is spanned by a fine iron roof, made by Messrs. Drew Bear, Ransome & Perks. We shall have something more to say concerning the measurements later on; in the meantime we will speak of the boilers.

The Boilers and Accessories.

There has been much discussion lately and much heat evolved on the comparative merits of Babcock and Lancashire boilers. Whatever may be the ultimate outcome of this controversy, the friends of the Lancashire type will be gratified to learn that the most advanced station in this country is provided with a battery of five steel Lancashire boilers. They are each 30 feet long and 7 feet 6 inches diameter, with furnace tubes 3 feet diameter. They have been designed strong enough to stand a daily working pressure of 160 lbs. per square inch.

A description of these—which are, of course, constructed by Messrs. Yates & Thom—may be interesting:—The shell plates are $\frac{23}{32}$-inch thick, the thickness of the furnace plates being $\frac{17}{32}$-inch thick; the end plates are $\frac{11}{16}$-inch thick, and the cover plates $\frac{23}{32}$-inch thick. The shell of each boiler is made in eight parallel rings of plates, the longitudinal seams in shell being treble riveted, and made with double cover straps having six lines of rivets; the ring seams, as well as the end plates, being double riveted. The furnace tubes are each made in 12 rings of plates, with 11 flange seam expansion joints. The end plates at both ends are solid, rolled in one piece, instead of being welded. The front end plates are attached to the cylindrical shell by external steel angle rings $5\frac{1}{2}$ inches by 5 inches by $\frac{11}{16}$-inch, and the back end plates to the shell by a flange formed on it by a hydraulic press. Each end plate is stayed to the shell by five gusset stays above the furnace and tubes, and two below at front and three below at the back; in addition, there are two strong longitudinal stay bolts from end to end of each boiler. All the rivet holes throughout the boilers are drilled and countersunk on both sides, and the whole of the shell plates, as well as the cover straps, are planed on their four edges. All the end plates, angles, and flue tubes, are turned on their edges, and the end plates bored out for furnace and flue tubes. The steel used throughout these boilers is of mild ductile quality, and made by the "Siemens-Martin" process. Each boiler is fitted with a full complement of mountings, with two 6-inch junction valves for duplicate ranges of steam pipes. The mountings are made to the Manchester Steam Users' Association's standard, and both boilers and mountings have been made under the M.S.U.A. inspection.

The question of the boilers, we believe, gave the engineers considerable trouble, and their determination to adopt the Lancashire type was taken after the most careful consideration. In conjunction with these boilers, "Vicars's" mechanical stokers and smokeless furnaces of the latest type are employed, and a point of special interest is the fact that they are fed by one of "Vicars's" patent fuel conveyors and elevators.

The question of fuel for the Portsmouth station was of the utmost importance. They had to face the problem of using expensive Welsh coal, which was something over 25s. per ton, or a cheaper coal with less combustible properties. They decided to use a cheaper fuel, and to dispense with the laborious methods of hand-firing. The coal, which is practically town screenings, costs about 9s. 6d. per ton, and it is expected to yield satisfactory results. Using this class of fuel, mechanical stoking and conveying is indispensable.

Thinking the matter of sufficient interest, we illustrate the end of the elevator, and will describe briefly the working of it. The fuel is delivered by cart into the coal store outside the boiler house, from whence it is picked up by the elevator buckets and deposited into the conveyor trough. This trough is fitted with Vicars's strong cast worm, which conveys the fuel along to the hoppers of the stokers, and is arranged so that the fuel may drop into each one of the hoppers as desired. When each hopper, or as many hoppers as required, have been filled with fuel, the elevator is thrown out of gear, it being started when a fresh supply is required. The fuel gravitates into two boxes at the bottom of the hoppers, and it is gradually pushed by reciprocating plungers on to the fire-bars, which by their movement carry the burning mass inwards, at the required speed. Such unconsumed fuel as reaches the ends of the bars, together with the ash and clinker, is discharged on to the bottom of the flues, where combustion is completed in due course. The fire-bars are 5 feet long, and their motion, as well as the feed of the fuel, can be regulated with facility. The whole stoking plant is practically automatic in action, and consequently manual labour is reduced to a minimum. The stokers and conveying plant are driven by two small high pressure vertical engines. Each engine of itself is sufficient to drive the plant, two being provided for reasons of safety. The damper in the main flue between the economiser and the chimney shaft can be regulated by the stoker while in front of the boiler. The boiler flues are duplicated, and in one of them is placed the three sections of the economiser having 288 heating pipes. The products of combustion may be passed through the economiser or through the second flue.

In the pump house are fixed three vertical 3-throw single-acting pumps for feeding the boilers, each being capable of delivering 1,600 gallons of water per hour to the boiler, against a pressure of 160 lbs. per square inch. The steam cylinder of each pump is $4\frac{1}{2}$ inches diameter, 8 inches stroke, the crank shaft being connected to the 3-throw pump shaft by cast-iron double helical spur wheels. The rams of each pump are of brass, $3\frac{1}{2}$ inches diameter and $4\frac{1}{2}$ inches stroke, and make about 60 double strokes per minute.

These pumps obtain the water from a large tank capable of holding 20,000 gallons, or they can obtain with equal facility a supply from the town mains. Portsmouth water, however, is particularly hard, and it is necessary to soften it before passing into the boilers. For this a water purifier, made by the Stanhope Water Engineering Company, Limited, has been provided, which will soften and treat 2,000 gallons of water per hour. The apparatus consists of a lime mixing and settling vessel, a softening vessel, clarifying tower, soda tanks, and automatic regulating and check gear. The cost of softening works out about one halfpenny per 1,000 gallons.

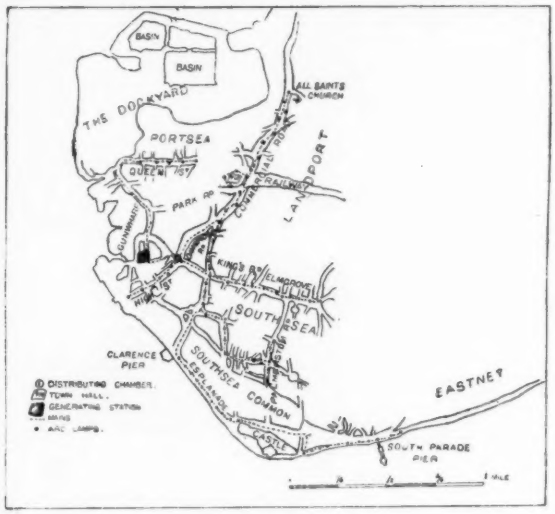
It is interesting to know that the scrapers on the economiser, as well as the stirrer in the water softener, are driven by a Brown's alternating current motor.

The steam pipes and steam pipe connections seem to have had considerable thought bestowed on them. In place of the usual ring system the engineers have devised two entirely separate ranges of main and branch steam pipes, and this double system of steam connection seems to have been carried out in the smallest detail, even the smallest engine having its double range of steam pipes. Of course this arrangement, albeit somewhat elaborate, minimises the possibility of the steam supply failing. The boilers are each provided with two standpipes, which terminate in stop valves, each of these stop valves being connected with each of the separate ranges running across the boilers. The main ranges have a through valve at the point where they leave the boiler. The steam pipes go to a common centre in the dynamo room, after which they traverse the room one over the other; branch pipes, 5 inches in diameter, connecting each range separately to the engine. A stop valve is provided at the root of each branch pipe where it joins the main; in addition there are two stop valves on the engine. To ensure the steam being freed from water when it reaches the engine, a water separator is inserted in each steam pipe, and at the extreme end of the steam pipe there are water catchers to catch the condensed water. In the construction of the main and branch pipes mild steel plates have been employed. In some cases these plates are one-third of an inch in thickness; they are welded longitudinally, and these welds are safeguarded by wrought iron rings, which are shrunk on to the lengths of steam pipe and then riveted. Expansion joints are not employed, the elongation of the main pipes being taken up by legs formed at right angles to the main pipes, these having sufficient elasticity to allow for elongation.

The Generating Plant.

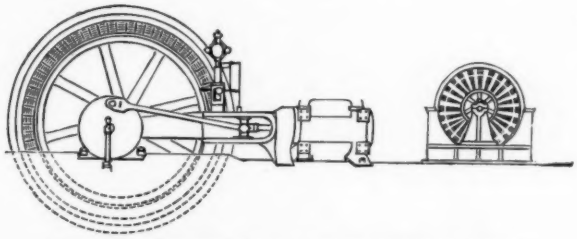
We now come to speak of the most striking feature of the Portsmouth station, the generating plant. It will be seen from one of the illustrations that it is difficult to speak of the alternators apart from the engines. We have already mentioned the reasons which led the municipal authorities to adopt this type of plant. While the plan of fixing F.M. coils on the rim of an engine fly-wheel is absolutely new to England, engineers on the Continent have had con-

siderable experience of this class of machinery, and at the Cologne station machines somewhat similar in type are used. The Helios Actien Gesellschaft, have been noted for a machine of this kind, and though it can scarcely be said that the magnetic field in this case is built on the rim of a fly-wheel, it is fastened to the crank shaft of the engine, its great weight enabling a special fly-wheel to be dispensed with. Apart from the fact that the Ferranti machine forms an



Map of District.

integral part of the engine, the arrangement of the revolving field magnet is interesting. Probably Lontin was the first to design a machine in which the field magnet revolved inside the armature, and the comparison between a Lontin machine of 1870 and a Ferranti of 1894, which is made in one of our illustrations, may be of some interest. The arrangement of the plant is such that we may almost describe it as an engine with a heavy fly-wheel, which, instead of driving a machine, generates incidentally, as it were, electricity on its rim. The efficiency of such an arrangement need scarcely be dilated upon. Before, however, we say

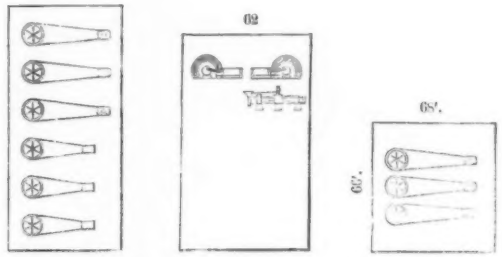


Comparison Between Lontin and Ferranti Machines.

more concerning the generator, we will turn for a moment to the engine. Although Messrs. Yates & Thom are, comparatively speaking, unknown to electrical work, they have adapted themselves with remarkable readiness and much skill to the erection of the Portsmouth plant.

The engines, then, are two horizontal side by side compound condensing. The fly-wheels, which, as we have already said, are utilised as the field magnets of the dynamos, being placed in the middle of the crank shaft between the two cranks. Each engine will give 320 indicated horse-power with a boiler pressure of 160 lbs. per square inch, when running at 96 revolutions per minute.

The high pressure cylinders are 15 inches diameter, and the low pressure cylinders 28 inches diameter, a 3 feet stroke being given. All the cylinders are steam jacketed in the bodies, lagged with planished steel, and fitted with "Corliss" valves and gear. The high pressure cylinders are provided with "Dobson's" patent automatic expansion "Corliss" valve gear, controlled by the governor, of which Messrs. Yates & Thom are the sole makers in this country, the low pressure cylinders being provided with "Corliss" valve gear with variable expansion, which is adjustable by hand when the engines are running; the steam valves in each case are worked independently of the exhaust valves. The piston rods are steel, and of $3\frac{1}{4}$ inches diameter; the crank shaft also, with main journals, is 9 inches diameter and 16 inches long, but is swelled up in the middle to 12 inches diameter. The crank shaft pedestals are cast with the foundation frames, and are fitted with gun-metal steps in four parts, with side wedges and screws for horizontal adjustment. The fly-wheels of both engines are 12 feet 9 inches diameter and $21\frac{1}{2}$ inches wide; they are made in halves, and prepared round the rim for 64 magnet poles. Each wheel, with bolts, hoops,

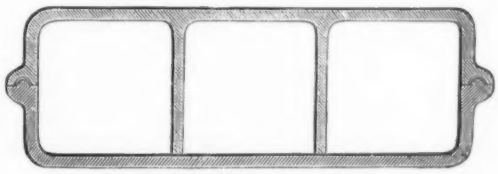


Comparison of Stations.

&c., but exclusive of poles and wiring, weighs about 10 tons. The air pump of each engine is vertical and single-acting, 19 inches diameter and $11\frac{1}{4}$ inches stroke, the working barrel being lined with gun-metal and fitted with a gun-metal bucket and rod. The bucket and delivery valves are of India-rubber, arranged on the multiple principle. The governor is of the quick-speed type, and fitted with Yates & Thom's improved isochronous motion for maintaining a uniform speed in case of varying steam pressure or varying condition of load on the engine.

Both engines are massively built, and are provided throughout with efficient means of lubrication; brass mounted oil drippers, neatly polished hand-rails and pillars round the working parts of the engines, complete the equipment of these remarkably fine motors.

The saving of space which the employment of this class of alternators with rectifiers for public lighting, is enormous; how much it really means may be gathered from a comparative sketch which we have prepared. We have



Conduits (Elevation of Ducts).

taken two of the best specimens of rope-driven machines in the country, Blackpool and Leeds. The nearest comparison as regards size is Blackpool, which is longer than that at Portsmouth, but of less width, yet the whole available space is taken up, the output being 320 units against the 570 units of Portsmouth, with only a fifth of the station occupied by machinery; extensions in this case are not considered. A study of the figures given with each station may be instructive.

The Alternators.

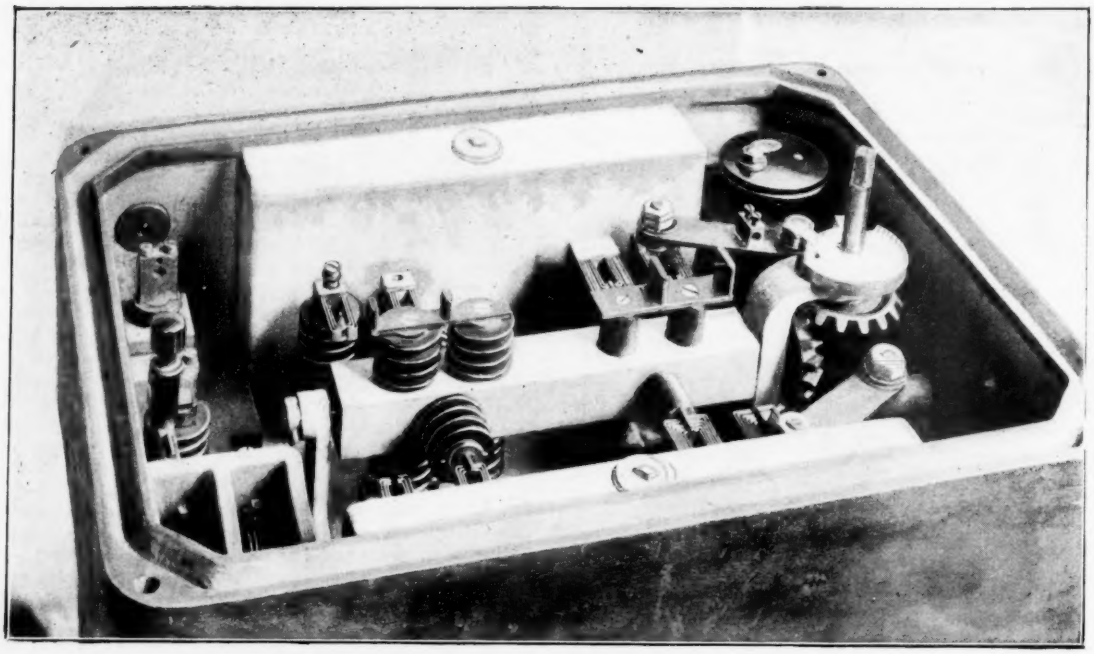
Each of the dynamos gives an output of 212 units at 2,100 volts pressure when running at 96 revolutions per minute. Each machine has 64 magnets, and consequently runs at a periodicity of 50 cycles per second.

The fly-wheel of the engine, as we have already said, has 64 recesses spaced true, radially formed to receive the lower end of the solid wrought-iron magnet forgings, each of which is secured in position by a $1\frac{3}{4}$ inch bolt passing through the

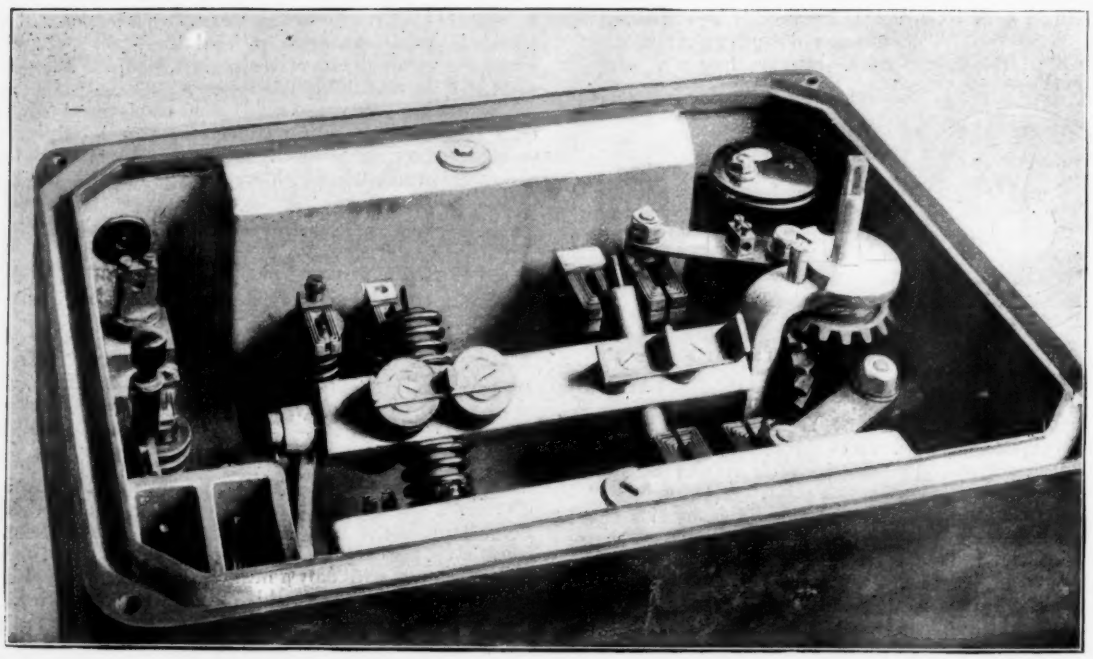
rim of the wheel. The wrought-iron magnets are machined all over, have enlarged pole pieces, and are each fitted with a steel steady pin to lock them in position.

The construction of the field magnet coils is novel; it consists of bare copper strip $1\frac{1}{4}$ inch wide by $\frac{1}{8}$th inch thick wound on its edge, the adjacent layers being separated from one another by paper rings shellaced and pressed into position, the coils being insulated from the magnet core and pole face by heavy fibre washers. The field magnets are all connected in series and are put on in pairs, the bottom contacts being brazed together, whilst the top contacts are made by copper angle-lugs. This form of field magnet coil combines good mechanical construction with electrical efficiency, as the edge of the bare copper strip is exposed to the cooling effects of the air, and the winding being only one layer deep there is thorough heat conduction from the inside to the outside, the proof being that after lengthened runs at full load the copper is scarcely warm, whilst the centrifugal strains are taken on flat surfaces.

The overall diameter of the field magnets is 14 feet 3 inches, and the exciting current at full load 100 ampères at 30 volts; there is consequently only a difference of potential of about 1 volt between the tops of a pair of adjacent field magnet coils, there is, therefore, no fear of short-circuiting due to water, or dirty oil, or other material, getting on the magnets while the machine is running, and indeed the construction would permit of the machine being cleaned, if desired, with a hose-pipe.



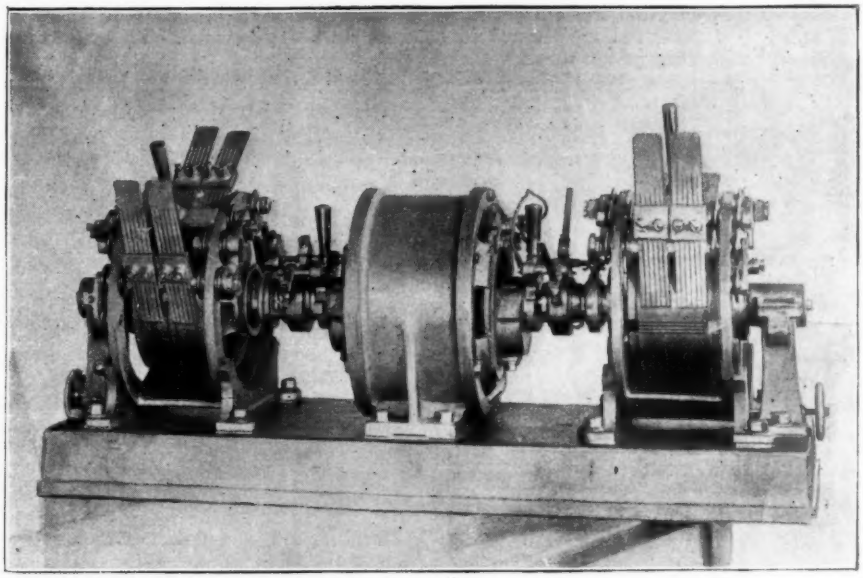
Transformer (in circuit).



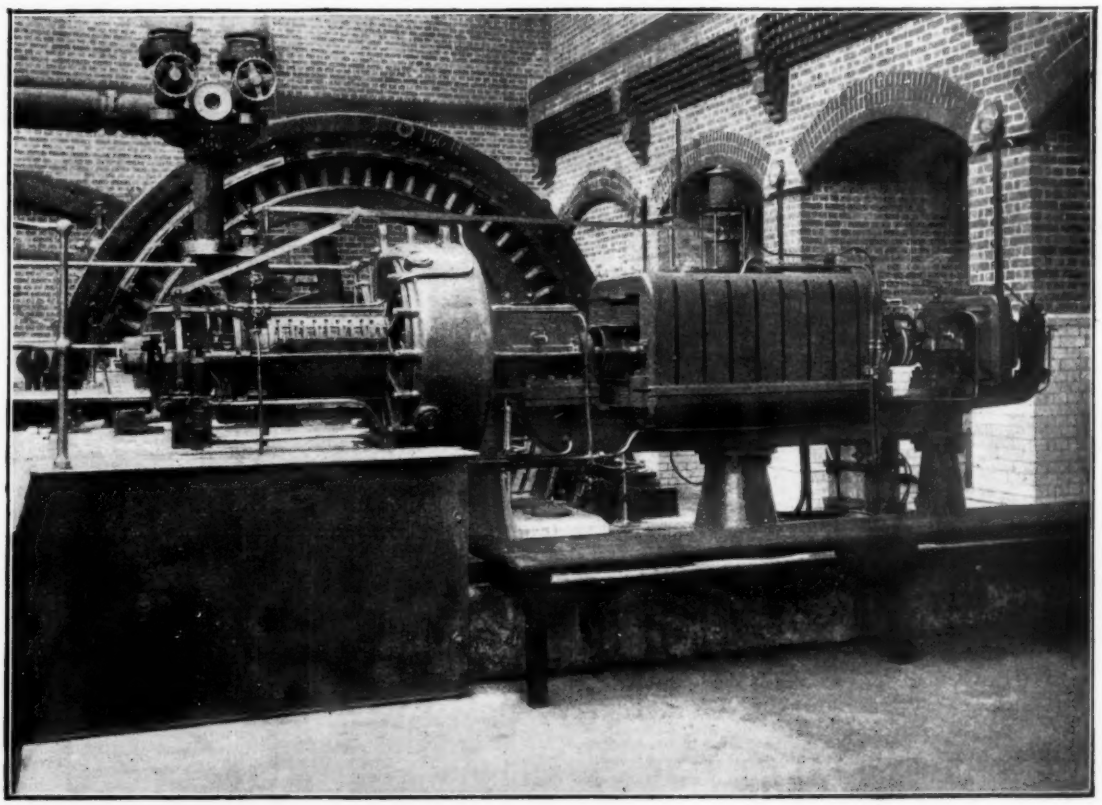
Transformer (out of circuit).

The armature frame which surrounds the outside of the field magnets is supported at both ends by a short massive base plate some 18 inches deep. A segment of the armature is illustrated. The frame is a heavy U-shaped casting in four sections bolted together, and machined on its inside and on the edges. There are 64 armature sections, each composed of a number of laminated Swedish iron stampings; each of these stampings (one of which we illustrate) is perforated with seven oblong holes and one circular hole. In the inside of four of these oblong holes mica tubes are fitted, the ends of the tubes projecting some three-quarters of an inch beyond the ends of the stampings. Of the remaining three holes one is left empty, and two are utilised for receiving two insulated manganese bronze bolts, by means of which the stampings are clamped together and the end boxes secured on. A gun-metal box machined on the top, bottom, and two ends, and having slot holes in the bottom corresponding with the holes in the stampings, is then fitted over the mica tubes; this box contains, in the inside, an ebonite insulator or distance piece, which also closely fits over the ends of the mica tubes, the whole being held in position by the two manganese bronze bolts passing through the laminated stampings.

The armature wire is wound through the mica tubes, the

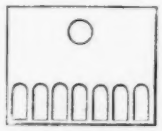


Rectifier.

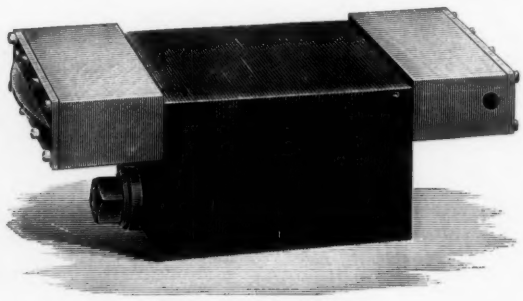


View of Turbo-Generator.

wire being passed through the two middle tubes first until they are filled, and afterwards through the two outer tubes; the ends of the winding in one box are finished off with a coned copper contact bolt insulated with ebonite, and the ends of the winding in the adjacent box have contact blocks with female cone to fit on to the bolts in the adjacent box. The contact pieces pass from one section to another through the circular holes bored in the ends of the gun metal boxes. The individual sections wound as described are then pressed into the U-shaped armature frames, and are secured in position by an insulated bolt which passes through the



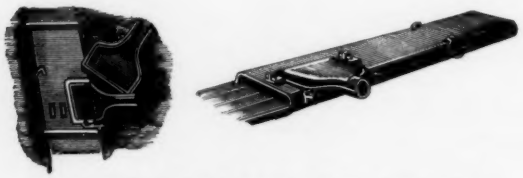
Section of Armature.



Segment of Armature.

flanges of the frames and through the circular hole at the top of the laminated stampings. Connection having been completed between the windings of two adjacent boxes, machined covers are then screwed on, and the whole of the winding of each armature section is thus enclosed in a completely water-tight case, thus preventing the winding being injured in any possible manner.

From this description it will be seen that the whole of the armature is entirely guarded against any accident, the wires being buried beneath the iron. Between no load and full load in this machine there is a variation of about 10 per cent. in the exciting current, and the machines run perfectly in parallel.

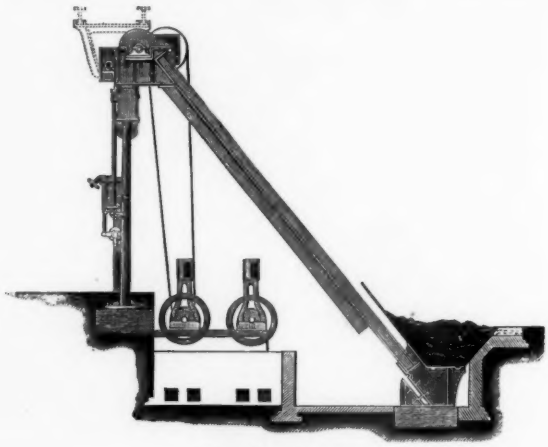


Conduits Showing Method of House Connection.

Some extremely interesting experiments were made as to the working in parallel of the slow speed Ferranti machines running at 96 revolutions per minute, and the Parsons turbine running at 3,000 revolutions; the results obtained were quite satisfactory, as the turbine ran perfectly in parallel with the slow speed machines; there was very little interchange of current, and by suitably manipulating the exciting resistances, the load could be divided equally between the two machines.

In order to demonstrate the solidity of construction, and the general reliability of the Ferranti dynamo under all circumstances, the drastic experiment was tried of running the machine on open circuit at full speed, and with the maximum exciting current at full load, a pilot voltmeter being in circuit to show that the full voltage was generated, and then switching a dead short circuit across the 2,100-volt terminals of the armature; a heavy rush of current of course occurred, but not the slightest harm was done to the machine; this was repeated on several occasions. The dynamo was also run for some minutes at full speed and full exciting current, with the armature short-circuited, with equally satisfactory results, thus showing that if two or more machines were connected in parallel, and that the exciting current of one of these machines should from any reason fail, that the armature of the faulty dynamo would not be injured in any way by the rush of current from the other machines, even if the fuses failed to act.

Each dynamo has a series wound exciter, made by the E.C.C., driven by cotton ropes, the driving pulley being fixed on the crank shaft of the engine. The exciters run at 400 revolu-



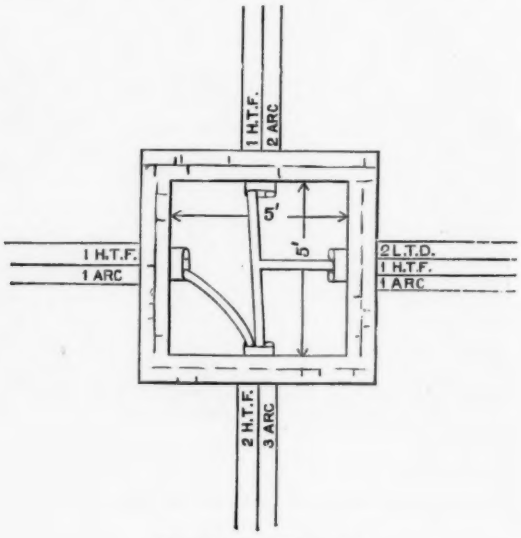
Coal Conveyor.

tions per minute, and according to the requirements of the specification, each gives an output of over 50 per cent. more than is required to excite one alternator.

The Switching Arrangements.

The current from the dynamo is conveyed by concentric cable constructed by the British Insulated Wire Company, Prescot, to the switchboard, being finished off both at the dynamo and switchboard end in special watertight glands.

The switch gear itself is a surprise to engineers accustomed to the general run of central station switchboards, occupying often one side wall of an engine room, and covering many square yards in area. It is constructed for controlling five 300-H.P. dynamos, five outside cable circuits, and two arc



Distributing Chamber.

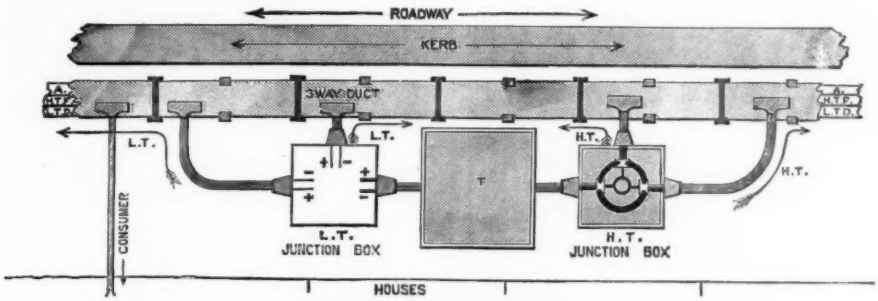
light circuits, and is complete with all the instruments, omnibus bar, pilot voltmeters, exciter resistances, &c., occupies a wall space of 6 feet wide by 9 feet high, and projects from the wall some 3 feet. It stands in the centre of the end wall, nearest the boiler house, and is raised on a

wooden platform, thus enabling the operator to have a clear view over the engines, &c.

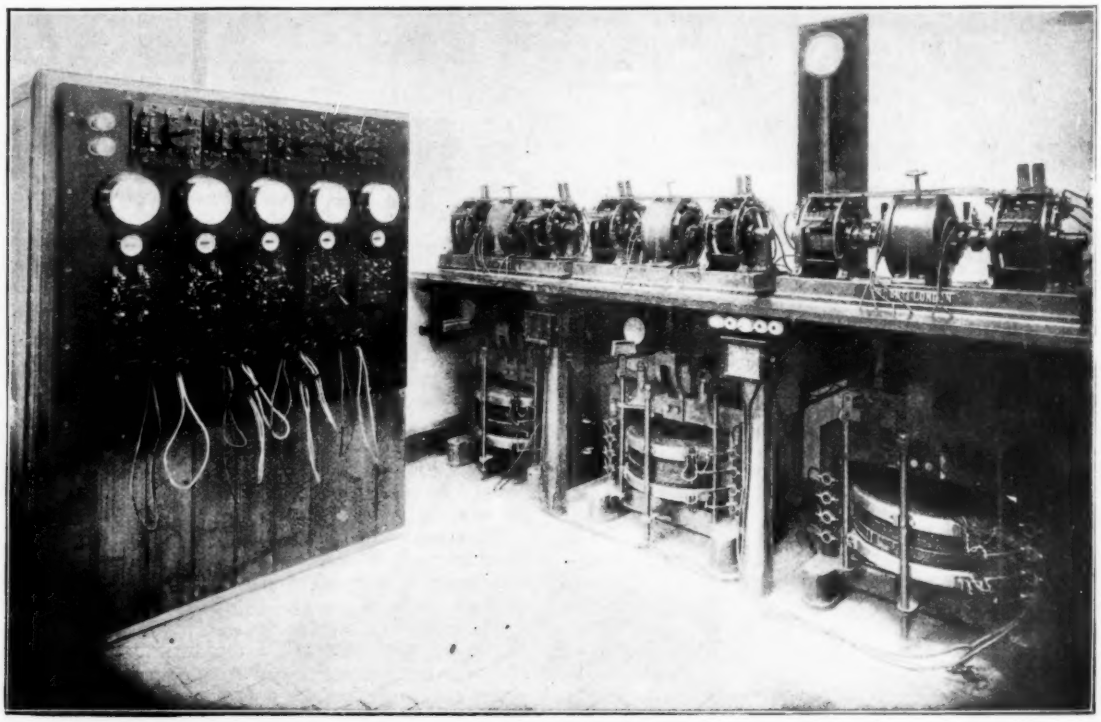
The concentric system of cables is adopted throughout Portsmouth, with the outer conductors insulated throughout, except at the main switchboard, where the negative omnibus bar, to which they are joined, is connected to earth. On reaching the switchboard the outer conductor of the concentric cable is connected to a G.M. gland box; each box is separately insulated on a solid slate division piece, but is connected to the adjacent gland boxes and to the negative omnibus bar by removable link pieces, thus normally all the gland boxes are connected together and to the negative omnibus bar; but for testing purposes each is separately disconnectable, whilst the omnibus bar is always connected to earth.

The inner conductor of the cable passes through a porcelain insulator in the slate division piece, and terminates in a spring fork, which forms one contact for the fuse plug, the other contact being on the underneath side of the dynamo switch, which is immediately overhead. The fuse consists of a stoneware trough, divided in half lengthways. On the outside end of each of the divisions so formed is a gun-metal plug for making connection with the two fixed spring forks on the switchboard, and in the inside of each recess or trough is a strong spiral spring, which is joined to the G.M. contact plug. The fuse itself consists of two rings united by a short length of copper wire; one of these rings is slipped over the end of each spiral spring, the copper wire resting on the top of the central division strip, and causing the spiral springs to be held in tension, and to exert a constant pull upon the fuse. The troughs are filled to within half an inch of the top with an insulating oil, entirely submerging the springs and copper rings of the fuse, leaving the fuse alone exposed to the air. When an excessive current is passed the fuse melts, the two springs come right down into the oil, and the circuit is immediately broken. This fuse acts with great rapidity and breaks the circuit so quietly, that for a moderate current, say up to 50 ampères, any one standing on the switchboard cannot tell, except by looking at the ammeter, when the fuse goes. At Portsmouth, currents of 120 to 150 ampères, at 2,100 volts, have thus been broken with the utmost ease.

The fixed fuse contacts are so designed that by inserting a removable plug the contacts are short-circuited, and the fuse pot can be bodily removed for the inspection or replacement of fuses, whilst current is passing. After leaving the fuse the current passes to the lower contact of the switch, which is only required to be single pole; this also is of special construction. The first motion on lifting the switch is to put the dynamo on to a synchronising bar, to which is connected a synchronising voltmeter in the usual way; when the new machine is synchronised with the machines already running, the switch is pushed forward further, and contact is made on to the H.T. omnibus bar through an ampèremeter fixed immediately above the switch, at the same time breaking connection with the synchronising bar; the switches are provided

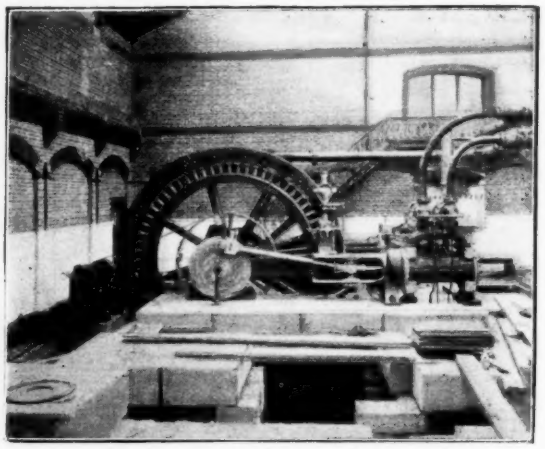


Plan of Underground Mains.



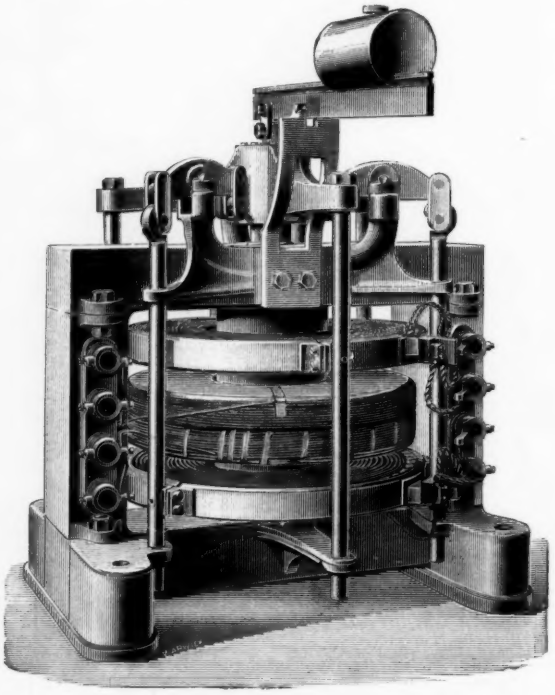
Commutating Room.

with a special quick breaking arrangement, and have a break of 9 inches clear; the parts conveying the current normally break first and get quite clear of the working surfaces before the final break is made, the current being meanwhile conveyed by a spring, which, on finally breaking, rapidly follows the main switch. All wearing parts are quickly removable, and being interchangeable, repairs can be rapidly done.



View of Machines in Course of Construction.

The whole of this switching gear is mounted on, and between, four thick pieces of enamelled slate let into the wall horizontally, and projecting from the wall surface some 16 inches, whilst movable vertical enamelled slate division pieces completely separate each fuse, switch, and ammeter from



Transformer for Commutators.

the adjacent ones, thus completely localising any damage in the event of a mishap, and permitting repairs or alterations to be safely executed to one section of the switching gear whilst the remainder are in use.

The top omnibus bar is of ring form and arranged to be divisible, enabling a circuit to be disconnected for testing purposes or for any dynamo to be tried on a dead load, or to run on one special circuit, irrespective of the other running plant.

The pilot voltmeters have 14-inch dials, and are fixed above the H.T. omnibus bar; each of them is mounted on its own special converter.

The circuit switches are in all respects identical with the dynamo switches above described, except that they receive current from the omnibus bar, instead of giving current to it, and have no synchronising contacts.

The exciter resistance frames stand immediately below,

Street Lamp Standard.

and slightly in front of the main switchboard, and each consists of a 40-point horizontal switch mounted on the top of a pillar.

A fixed tube in the centre of the switch supports the exciter circuit ammeter; thus an operator when working the exciter switch has under his eyes the amount of exciting current and the volts on the synchronising and omnibus bars. The front of the resistances is cased in with a handsome panelled teak frame, and the floor of the switch platform is covered with inlaid wood parquet, as are also the semi-circular steps leading up to it.

The main switchboard itself is highly finished in all respects, and with its enamelled slate divisions has a handsome appearance, is as simple as possible, and is the outcome of extensive experience.

The current for the five outside circuits, previous to leaving the works, passes through a recording instrument fixed in the recorder room, which shows graphically the output of each circuit, and the voltage on the omnibus bar, at any hour of the night or day.

The Use of Rectified Currents.

What is of special interest is the fact that the whole of the public lighting is done by rectified currents. Two circuits from the main switchboard are taken direct to the arc light switchboard in the motor commutator room, a view of which is given, feeding on the way two converters, one on each circuit, which supply the low tension current for running the synchronous motors of the "motor commutators" or "rectifiers."

The switchboard is arranged for four motor commutators and five circuits; the top is occupied by four three-contact

two-way switches, each of which controls one motor commutator, and enables any, or all, of the commutators to be run on either of the two arc light mains. Two of the switch contacts are for the low tension current which runs the motor, and the third for the high tension supply to the constant current arc light converter. Below these switches is a row of five ammeters, pole indicators, high tension reversing switches, and circuit sockets, being one complete set for each of the five arc light circuits. Underneath are four pairs of plugs, with flexible cable attached, allowing the rectified current from any motor commutator to be connected on to any circuit, whilst any circuit can be coupled in series by a pair of independent plugs joined by a flexible.

At the extreme bottom are two pairs of instrument plugs and flexibles, one pair to be used with a Kelvin 3,000-volt electrostatic voltmeter for testing the potential across the arc light mains, or between one main and earth; the other pair of plugs puts a Kelvin balance in series with a circuit ammeter, to permit the readings being checked.

The Ferranti motor commutator itself, which we illustrate, consists of a synchronous, self-starting, alternating current motor, fitted with the necessary commutator for rectifying the current required to excite its own field magnets, and fitted at each end with a special form of commutator for rectifying the current required for the outside arc lamps. In the case of Portsmouth, each commutator is arranged for rectifying the current for 20 12-ampère lamps, and the two commutators, one at each end of the motor, are connected in series, thus enabling 40 12-ampère lamps to be run in series. A considerably higher E.M.F., say, from 2,400 to 2,500 volts, has been used at Portsmouth, some of the circuits having been coupled in series to make a circuit of from 48 to 50 lamps, in addition to an unusually long length of outside cable; as a matter of fact, as many as 40 lamps, requiring, say, 2,000 volts, have been run off a single commutator most successfully, so that there is an ample margin of safety.

The commutator consists of two double-winged castings, mounted on opposite ends of a short spindle, on which they are independently fixed and insulated, the wings of the two castings interlapping.

When thus mounted, the periphery, sides, and rings are turned in a lathe, and are consequently true with one another.

Removable copper segments are then screwed to the periphery, and the clearance space between two wings is partly filled with insulated copper angle strips, whose object is to prevent the fixed collector brushes from jumping when passing from one wing to the next.

The commutator is again turned, balanced, mounted in position, and then ground to ensure absolute truth.

As above explained, each commutator is complete on its own spindle, of which one end forms a female cone, and fits accurately a corresponding male cone turned on the motor shaft.

This system enables a worn commutator to be removed in a few minutes and replaced by a spare one, and for fresh copper segments to be fitted at leisure to the worn one.

This is but seldom requisite, as the segment pieces are thick, and a special grinding attachment enables a commutator to be ground in position on its own motor, should the surface of the copper become scored or untrue.

Surrounding the commutator and concentric with it, is the cast-iron brush-holder frame carrying four sets of brushes, the two double laminated brushes receive current from the special arc light converter and convey it to the commutator; the remaining two brushes pick up the commuted or rectified current, whence it flows to the switchboard.

As the two commutators, one on each end of the synchronous motor, are in series, their brush-holder frames are connected together by a cross bar, so that they can be moved simultaneously and rocked round the commutators to secure the best point of commutation, a locking screw fixing them in the desired position.

Each brush-holder has a screw attachment to enable any desired amount of pressure to be put upon the brushes, which can also be kept clear of the commutator when the motor is running light, or as spare.

The periodicity at Portsmouth of the alternators is 50 cycles per second, or 6,000 alternations per minute, and to commute this current the motor commutators have four wings, and run at 1,500 revolutions per minute; for higher periodicities six and eight-winged commutators are employed. The motors are carefully balanced, and lubricated with automatic ring oiling gear, and are stated to run for weeks without requiring any fresh oil.

The success of this system of lighting depends almost entirely on the perfect synchronous running of the motors, so that it is most desirable that the engine driving the main alternator should have a very even turning moment; if this is not done the motors have a tendency to hunt, as they cannot follow the uneven turning of the engine sufficiently rapidly. Any hunting naturally causes a longer spark than necessary at the brushes.

At Portsmouth a very even drive is of course secured by the heavy engine fly-wheel and magnets mounted on it, and the sparking at the main brushes is hardly so much as with a Brush machine; the surface of the commutator is stone cold after several hours' run, and the tips of the brushes are unburnt and do not wear away at all, and after running for some days the commutator becomes beautifully burnished.

The motor is self starting, the starting switches and resistances being fixed underneath the table; the small commutator on the motor for rectifying the current required for its own field magnets sparks somewhat until the motor attains synchronous speed, and then it becomes absolutely sparkless.

The whole operation of starting the motor, switching on the lamps, &c., is an extremely simple one, and readily learnt by the ordinary attendants.

For supplying current to the commutators a special converter, which we illustrate, is employed; this gives a practically fixed or constant current in its secondary circuit, with an E.M.F. varying according to the load on the secondary, and thus is the converse of an ordinary transformer, which gives a fixed E.M.F. and varying current.

The Ferranti constant current converters are constructed to give 12 ampères with 40 lamps in circuit, say 12 ampères at 2,000 volts, and the current only rises to 14¼ ampères on a dead short circuit; thus it will be seen that the accidental extinction of one or more lamps would make no difference to the current passing through the remainder, especially as an adjustable counterpoise weight, fitted on the top of the converter, allows any desired regulation to be made.

The converter consists of a circular laminated iron core, standing vertically, and fitted with a top, bottom, and two end pieces also of laminated iron.

Four flat coils surround the core; two are primaries and two are secondaries, the latter being fixed rigidly round the centre of the core, whilst the primary coil above and below them is movable, and is each separately suspended free of the iron core and sides by three brass rods, arranged vertically in the form of a triangle.

The three brass rods of one coil are bolted at the top on to a 3-arm star piece, the boss of which is bored out and forms an air cushion with a projecting stem on the converter top; the lower ends of the rods are held in guides which allow them and the star piece to lift vertically.

The three rods attached to the other coil are hung by links, fitted with knife edges on to rocking levers.

The latter, fitted centrally on knife edges, rock on arms projecting from the converter top casting, and at their inner ends are attached by similar links to the star piece; thus it will be seen that the primary coils balance one another on the rocking levers, and move equally towards or away from the fixed secondary coils; the total vertical movement of each primary coil is some 4 inches.

The primary coils are so weighted that they just float clear of the secondary coils when 12 ampères passes through the latter; should the secondary current increase, the repulsion becomes greater, and the primaries move away, and so reduce the secondary current by causing more of the lines of force of the primary coil to be diverted.

A counterpoise weight, rocking on an arm bolted rigidly to the converter top, permits weight to be added to or taken from the moving coils, and so regulates the current in the secondary to a nicety.

When the engine is running lightly loaded the sudden addition of some 40 horse-power, by switching on an arc lamp circuit suddenly, might tend to pull up the engine and so cause a jump in the lights; consequently a water break-

switch is used in the primary of the converter, and so by gradually cutting out the water resistance the load can be put on over two or three minutes, and thus allow the engine to take steam properly.

The Street Lighting.

Brockie-Pell arc lamps, of the standard double-wheel 32-hour type, are employed, except that instead of the solid core, usual with a continuous current lamp, a laminated core is used in the main circuit, as a solid core gave slight local heating, which although of no importance, it was thought better to avoid.

There are 100 arc lamps now installed, lighting the principal streets of Portsmouth and Southsea, and the fine effect, splendidly steady running of the lamps, and increased illumination obtained, has given such universal satisfaction that an immediate increase is contemplated.

The sea front, from the Esplanade Hotel to beyond the new Southsea pier is lighted with 21 lamps, spaced some 90 yards apart, and the effect is particularly good, demonstrating clearly the great advantage of using 12-ampère arc lamps over the usual 10-ampère lamp.

The lamp-posts, which have been designed by Messrs. Drew Bear, Ransome & Perks, are light and elegant, and are surmounted by the standard Brockie-Pell carrier. Cross-arms are provided for leaning a ladder against, but usually the lamp trimming, &c., is done by means of removable climbing steps, carried round by the trimmer.

All the lamp-posts, with the exception of those along the sea-front, have two brackets fitted underneath the cross-arm, each carrying a 32-C.P. incandescent lamp encased in a special water-tight fitting, and provided with reflector.

These lamps will be switched on and lighted from the general low tension mains about 12 o'clock every evening, when the arcs will be put out; this can be done from outside the post with a special key.

The lamp-post base is fitted with a hinged door, giving access to the arc switch, and the switch and fuse for the incandescents.

We ought to mention here that the recording ammeters and voltmeters used at the central station are of a new type, made by Nalder Bros. & Co.; they are mounted in a handsome polished teak case about 5 feet 6 inches long, and 6 feet high. In this there is a steel spindle, having three cylinders attached to it, with needle points, which grip the three papers, and pull them over a flat plate of brass rollers. The pointers of the nine instruments—six ammeters and three voltmeters—draw on the paper where it passes over the flat plate with recording pens. The spindle is driven by clock-work, at such a rate, that for the whole day there is a record 42 inches in length, giving $\frac{1}{40}$-inch per minute. In the bottom of the case there are also high tension two-way switches, arranged for first short-circuiting the ammeters, and finally cutting them completely out of the circuit. The voltmeters, which work at the supply pressure, viz., 100 volts, are provided with suitable switches and fuses.

Parsons's Turbine.

We must not omit to speak of the Parsons condensing steam turbine alternator, which has been designed for an output of 150 units. This compound steam turbine is arranged for multiple expansion from the 160 lbs. per square inch boiler pressure, down to a condenser pressure of $\frac{1}{2}$ lb. absolute, or a range of about 300-fold expansion. It revolves at a comparatively low speed—3,000 revolutions per minute—and is coupled direct to a two-pole alternator, giving 75 ampères at 2,000 volts, with a periodicity of 50 complete periods per second. It stands on rubber blocks, which rest on a concrete foundation, without any holding down bolts whatever. An automatic variable cut-off valve gear and governor, electrically controlled, maintains a constant E.M.F., and enables the full range of expansion to be maintained at light loads, thus securing exceptional economy of steam on the all-day load. The condenser is of the jet description, but differs somewhat from the usual type. A separate water pump is placed below the condenser, no injection water proper being admitted to the air pump, which is placed above, and is compound. By this arrangement the vacuum obtained is better than is usual with jet condensers, and at the same time the power required to work the pumps is considerably reduced. The pumps are worked from the crossheads of a small tandem compound auxiliary vertical engine, with cylinders 4 inches and 7 inches diameter, and giving a 12-inch stroke, supported on girders, so as to stand on the footplate of the engine room above. The exhaust from this engine can be sent either into the chimney or into the condenser. Valves are arranged so that both the steam turbine alternator and the condenser engine can take their steam from either range of steam pipes, and so that the steam turbine alternator can be run high pressure in case of the injection water failing, or other cause. This turbine is chiefly remarkable as being the largest of its type ever built.

The Method of Distribution.

The map of the district shows clearly the area of the mains, which have been laid on the Johnstone system.

Two main feeders run from the central station to a distributing chamber in Cambridge Junction, shown in an illustration, where one branches off to Commercial Road and the other supplies High Street, King's Road, Elm Grove, the Terraces, and Palmerston Road, thus dividing the system at that point into two circuits. The Portsea circuit is a separate one and is supplied direct from the station. High tension junction boxes as well as low tension ones and transformers being constructed in each circuit, the high tension mains are cut and connected on to special copper rings in the junction box, which are at the same time connected to one side of the transformers. The low tension cables are similarly handled on the other side of the transformer, thus reducing the voltage for the supply of consumers and the incandescent street lighting. The arc lighting is supplied from another cable (·0229 square inches concentric), and is divided into three circuits, each circuit averaging about 34 lamps.

The cables used for outside work have been made by Messrs. Glover, while the whole of the cables used inside the station have been made by the British Insulated Wire Company. The high tension feeders range between ·0229 and ·2 square inches sectional area of copper, and are all concentric, with the best rubber insulation testing 5,000 megohms per mile, after a minute's electrification in water at 60° F., while the low tension cables are in pairs, and therefore not concentric, ·0349 square inches sectional area.

The lamp joints are made in the drawing-in boxes by the lamp-posts. All the running joints and lamp joints were made by Messrs. W. T. Glover & Co.'s jointers, the drawing in of the cables and other matters being superintended by Mr. Basil Gee.

Our illustration shows the arrangement of mains from the high tension junction box to the consumers' premises.

The high tension feeders go in and out of the junction box, though connected to the transformer, to carry power further to another transformer, and so on.

Transformers.

The surface of the pavement is broken in three places for road box covers, viz., for the transformer, high tension junction box, and low tension junction box.

The high tension junction box permits of the current being entirely cut off a transformer, whilst allowing the main to be continuous and to feed other transformers farther on.

The low tension box enables the mains to be cut in sections or connected together continuously, and thus facilitates connecting customers or finding faults.

Two types of Ferranti transformers are used, namely, the automatic type and the hand change over type.

We will describe the hand change over type first. The concentric cable passes into a top chamber through a water-tight gland, and the outer conductor is then connected to an insulated terminal; the inner conductor is carried through and terminates on one end of a removable switch, which thus permits the high tension cable to be cut off from the rest of the converter; it then passes through an oil-break fuse of similar construction to those employed on the main switchboard, and finally reaches one terminal of the converter.

The converter is wound in two sections, both in its primary and secondary coils, the ends of the sections terminating in eight highly insulated copper rods, carrying at their upper end a modified split ring contact. At times of light load the two primary sections are connected in series, as are also

the two secondary sections; but for outputs beyond quarter load the respective sections are connected in parallel.

This is done by means of an ingenious commutator, mounted on two small standards, and occupying the central portion of the chamber. It is actuated by bevel wheels, the upper one carrying a vertical shaft with squared end, which passes through a watertight gland packing.

The converters are installed in a brick pit or chamber built under the pavement, and covered with a road box having its covers in halves. A circular hole in one half cover enables a road key, exactly similar to those employed by turncocks, and fitting on to the squared end of the projecting commutator shaft, to be used for turning the commutator from series to parallel, or *vice versâ*.

Supposing the converter to take a magnetising current of 1 per cent. with the coils in parallel, it will only take one-third of 1 per cent. with the coils in series, thus you save two-thirds of 1 per cent. at all times of light load, or a proportionately greater amount if the magnetic current at full load exceeds 1 per cent. Thus the converter would be most economical if the load factor of the station were 25 per cent. These converters can be changed over every day to suit the load requirements, or can be left permanently over in series during the light or summer months. A Cardew safety device is installed in each converter, which are of 15, 20, and 30 kilowatt sizes; consequently comparatively few are required for lighting a town, when the larger sizes are employed.

The body of the converters is immersed in oil, and by a simple arrangement is always under a slight head of oil, to replace leakage, &c. The entire converter and commutator is in a water-tight case, and appears a first-class job.

The automatic converter is the one preferred by the Ferranti Company, and is the change-over type, brought to the utmost perfection.

Here the converter is wound in three sections, in both primary and secondary, which are respectively connected all in series or all in parallel. By this means the magnetising current is reduced from, say, 1 per cent. at full load to one-fifth per cent. at tenth load, and the converter is most economical on a 10 per cent. station load factor, which is the average factor of most central stations. The change over in this case, however, is done automatically.

The low pressure end of the primary coil passes round a relay, which, when the current passing exceeds a given amount, causes a mercury contact to be made, switching on a small alternating motor.

This motor is connected by means of gearing to one end of a strong helical spring, the other end of which gears with the commutator shaft.

The motor runs round and winds up the spring strongly; a catch lifts, and the commutator is quickly rotated a quarter of a revolution by the stored energy in the spring, and changes the connections from series to parallel.

The contact to the alternating motor is then automatically broken, and cannot again be made until the current in the primary falls to one-tenth load, when the operation is repeated, and the connections changed to series.

The action is very pretty, and Messrs. Ferranti claim that with it they can guarantee that over 90 per cent. of the energy generated in the station, can be delivered to the customers. The actual figures obtained, &c., would fill up too much space for us to be able to give them in the present description, but the question is worthy of serious study.

With regard to supplying consumers, it is only necessary to say that from the transformer two pieces of 37/12 are brought into the low tension junction box on to two bars, + and −, which carry 6 or 12 thimbles, the low tension cables lying in the duct being brought into this junction box. There may be only one pair of low tension mains feeding consumers on one side and in one direction, and two or three pairs feeding in the other direction, as is shown by the arrows. The number of pairs of low tension cables is according to the quantity of consumers, within a space of, say, 150 yards from the low tension junction box, or from the transformer. The consumers within that space are tapped on to the low tension mains with a T-joint.

How the Mains are Laid.

The conduit in which the mains are laid is a cast-iron structure composed of two troughs, one placed upon the other, a groove being cast upon the edge of the lower and a tongue on the edge of the upper length, so that when put together they exactly fit. These sections are five feet in length, with the exception of the half-lengths, which are used on entering and leading out of the drawing-in boxes, so as to break joints. The groove on the edge is filled with putty, which becomes perfectly hard, and the edge of the top trough, being tongued, fits firmly down upon it. The two troughs are fastened together by means of clamps (which hang on to lugs cast on the troughs) and recessed straps filled with putty, these latter surrounding the abutting ends of the troughs. The clamps and straps are keyed together by means of wrought-iron wedges; in this way the conduit forms a solid structure, which will bear the weight of street traffic. The whole of the cast-iron work is coated with Dr. Angus Smith's preservative solution, which renders it very durable. The section of the conduit which leads into and out of the drawing-in boxes (which are placed about 70 yards apart, and at street corners), are made round instead of square, like the rest of the conduit; in this way a possibility of injuring the insulation of the cable when it is being drawn in is avoided.

In those streets where the conduit is divided into three ways it accommodates arc light concentric cables in the side nearest the street, high tension concentric cables in the middle duct, and low tension distributing cables on the side nearest the houses. By removing a top length, all the cables can be reached at any point along the line.

The Johnstone system is especially convenient for making house connections at any place. This is done by means of hand-holes, which consist of an opening in the top length large enough to give access to the cables. The opening is covered with a spigot piece to which a pipe is connected which leads into the house. These hand-holes have been laid opposite nearly every shop in Palmerston Road and the other principal streets of the town; and in this way provision has been made for lighting the premises at a very small cost. In places where it is necessary to insert hand-holes after the conduit has been laid, this can be done by removing an ordinary top section and replacing it by another supplied with a hand-hole. This method of making house connections is one of the chief points of the Johnstone system; it avoids the necessity of breaking a casting, or taking up long lengths of streets, or of including a large number of street boxes, which is the case with other systems.

In all streets ample room has been allowed for drawing in fresh cables when the necessity arises.

The work of laying the conduit is quickly carried out, as the several ways of the conduit are laid at one operation, whereas if separate pipes had been used it would have been necessary to have made three separate lead joints in every three yards of street work. In spite of the fact that the streets in some places were very narrow, and cellars came near to the surface frequently, all the obstacles were satisfactorily overcome.

It should be pointed out that very heavy cables were drawn into the conduits without any sign of abrasion.

At certain places in the town junction boxes of the latest and most improved design have been laid, and here again the handholes of the Johnstone system have proved most convenient for leading the cables out of the conduit, through the junction boxes and back again into the conduit, without breaking a casting or destroying the continuity of the conduit.

This portion of the work has been carried out by Mr. M. R. Margesson, the managing director of the company. Various portions of the conduits are shown. We ought to mention here that the whole of the out-door work, viz., laying the conduits, drawing in the cables, erecting lamp columns, fixing transformer and junction boxes, and connecting up to consumers, &c., was carried out by Messrs. Reid Brothers, under the superintendence of Mr. E. J. Reid.

The Testing Arrangements.

In a beautiful room off the engine house the testing arrangements are carried out. The testing set consists of a complete set of instruments by Messrs. Nalder Bros. & Co., mounted on a polished teak table, with the exception of the galvanometer, which is at top on an independent pillar. The instruments are joined up with plug switches, so that by the mere change of a few plugs the following tests can be made

viz., conductivity, insulation, and potentiometer tests. The instruments consist of a square glazed case galvanometer and shunts, electric lamp and transparent scale, a large size Wheatstone bridge, 100,000 ohm resistance coils subdivided into four coils of 25,000 ohms each, two Carhart-Clark standard cells in one case, reversing key, double contact-bridge key, double key with high resistance in circuit for use with standard cells, and various plug connectors and pillar terminals. On trays beneath the table are placed 10 Léclanche cells for use with the bridge, and 90 small dry cells to put in series with them for insulation tests. The electromotive force of these cells can also be taken by comparing them potentiometer-wise against the standard cell.

The ammeters and engine room voltmeters are of Messrs. Nalder Bros. & Co.'s usual alternating type; the voltmeters, however, have large faces 12 inches in diameter.

Those ammeters which are in the machine circuits feeding the 'bus bars are provided with a new special patented damping arrangement, which effectually checks oscillation, usually so annoying to the station engineer.

General.

Mr. H. Martin has been resident engineer for the Ferranti firm, during erection, under the supervision of Mr. H. W. Kolle, and Mr. Ferranti himself has lately been at Portsmouth directing the final completion of his work. Mr. Price, we ought to mention, is the engineer to the Corporation.

The comparison shown between the Lontin and Ferranti machines would have been more strictly correct if the drawing of the Lontin had been made a shade smaller.

Last Wednesday, in the presence of a distinguished throng, the works were formally opened, and the ceremony may be fairly termed a red letter day in the history of Portsmouth. Besides a host of electrical men, the Lord Mayor of Dublin, the Bishop of Portsmouth, the Countess Clanwilliam and other notabilities saw the switching on performed by the Mayoress, Mrs. Emanuel. The speeches were distinctly good; they were happily conceived and neatly expressed. The Lord Mayor of Dublin spoke of their own undertaking, and Alderman Ellis, the Chairman of the Electricity Committee, in the course of some remarks, dwelt upon the difficulties which had stood in the way of introducing the electric light into Portsmouth, one of the chief difficulties being, apparently, the superabundance of technical advice, even this difficulty being at last overcome. Dr. Garnett and Mr. Ferranti addressed the gathering in their respective capacity of engineer and contractor.

In the evening a grand banquet was given at the Town Hall by the Corporation, over 200 guests assembling. The speeches over, the majority proceeded to drive round the town to witness the lighting effects, and very pleasing they were; but spite of the brilliancy and steadiness of the street lighting, the most interesting place was the central station, where one had an opportunity of witnessing the whole system in full swing. From start to finish the whole proceedings went without a hitch, and we extend our hearty congratulations to all concerned in this unique enterprise.

LEGAL.

Alabaster and Others *v.* Harness and Others.

In the Queen's Bench Division of the High Court of Justice on Saturday, the 2nd inst., before Mr. Justice Hawkins, this case came on for further consideration in reference to questions of law.

Mr. Lawson Walton, Q.C., and Mr. Banks appeared for the plaintiffs; Mr. Jelf, Q.C., and Mr. Dodd for the defendants.

The plaintiffs, who are the proprietors of the Electrical Review, took part in the discussion as to Harness electrical belts, and in connection with this matter there had been litigation between them and Mr. Harness. In the Electrical Review there also appeared a review of the pamphlet published by Dr. Tibbits, who had some connection with the defendant. Dr. Tibbits thereupon brought an action against the plaintiffs for libel in reference to some passages in that review, but the verdict and judgment in that case were for the present plaintiffs, with costs. The costs which these plaintiffs incurred were, as between solicitor and client, £596, and as between party and party, £435. What the plaintiffs now complained of was that the defendant had instigated Dr. Tibbits to bring that unfounded action against them, and had thus put them to great expense in respect of costs, they having been unable to get payment of their costs from Dr. Tibbits. On the other side, it was contended that the plaintiffs had made out no case; that it had not even been shown that there was no common interest between Mr. Harness and Dr. Tibbits involved in the action for libel which the latter had brought against the plaintiffs. Without this being shown, it was submitted that the plaintiffs could not succeed in the present action for "maintenance."

Mr. Dodd, on behalf of the defendants, said that there were really two questions for the Court: (1) whether the defendant had a common interest with the Dr. Tibbits in the libel suit against the present plaintiffs, and (2) if not, whether he believed he had such interest?

Mr. Justice Hawkins thought that the defendant would have to show that he had a common interest, because he might be a very weak-minded person, and think he had an interest in everything. (Laughter.)

Mr. Dodd submitted that some of the cases went as far as this—that there could be no action of maintenance against any person who had done what he did innocently. The facts in this case were that Dr. Tibbits had been retained by Mr. Harness, as managing director of the Medical Battery Company, to make a report as to the electric belt. Dr. Tibbits was paid 100 guineas for the report, which was published at Mr. Harness's expense, or that of the company, and distributed broadcast through the country as an advertisement. Mr. Harness therefore had an absolute ownership in this pamphlet, and if the character of the man writing it were attacked, he was clearly interested in showing that the attack was unjustifiable and untrue. Under these circumstances he submitted that the defendant (Harness) beyond doubt had a common interest with Dr. Tibbits in establishing against the present plaintiffs the action for libel upon the review of Dr. Tibbits's pamphlet.

At this juncture, Mr. Dodd having concluded his argument, it was arranged that Mr. Lawson Walton should reply on the following Wednesday.

When the matter came up for further consideration on Wednesday,

Mr. Lawson Walton, in replying on the whole case, said that he should like to preface his immediate contention by a brief reference to the facts proved in the case. At the time Dr. Tibbits issued his writ, an action was pending between Mr. Harness and the Electrical Review. Mr. Harness had challenged the attack upon him in that newspaper, and upon the medical appliances which he was then selling, so that his interest in that business and his character as the vendor of these appliances was the subject of litigation actually in existence at this time. Instead, however, of pursuing his remedy in that action, Mr. Harness decided to assist Dr. Tibbits in maintaining an action. Dr. Tibbits's action was one for libel upon his character as a medical man. The article complained of was headed "Electricity and the Medical Profession," and he might fairly summarise it by saying that it reflected upon Dr. Tibbits's competence as an electrical expert. It said, in effect, that he was grossly ignorant of electricity, or grossly careless, and that owing either to ignorance or carelessness he had assisted in promoting the sale of articles which professed to have electrical properties, but which, in fact, had none at all. That was the litigation which Mr. Harness decided to support, and he should hope to satisfy his Lordship that he had no interest in it within the meaning given to that term by several decided cases. It was conceded that if he had no interest in that litigation, the action on his part was one of maintenance, and that the plaintiffs were entitled to succeed. The interest needed to deprive an act of its character as an act of maintenance was defined by the Lord Chief Justice in the case of Bradlaugh *v.* Newdegate, and, indeed, in all the cases the interest spoken of was an actual valuable interest in the result of the suit itself either present, contingent, or future. It was not contended that the interest in the present case fell within the classification of a charitable interest, or one arising from affinity or relation or connection between the parties. It was alleged to be a proprietary interest.

Mr. Justice Hawkins: The case stands absolutely upon the question whether there is such an interest as is necessary to rid the case of the charge of maintenance. No question arises as to charity, relationship, or obligation of any sort or kind.

Mr. Walton said it was necessary that Mr. Harness should have a valuable interest in the result of the suit itself. He submitted that Mr. Harness would have no such interest. The suit was one brought to place money in the pockets of Dr. Tibbits for the damage which his reputation had suffered as a medical man, and it would be doing violence to the definition of valuable interests to say that Mr. Harness had any valuable interest in the damages which Dr. Tibbits might have recovered. He understood it was contended on the other side that it was enough to show that the defendant was interested in discussing or establishing certain of the issues involved in the action.

Mr. Justice Hawkins: The issues involved are collateral issues.

Mr. Walton: If the defendant was to have an interest in the case on its collateral issues, the door would be open far too wide. One could easily imagine cases in which this method would be adopted to injure, say, a competitor in trade. There is one other point apart from the consideration of maintenance. I submit there is authority for saying that to maliciously assist an insolvent plaintiff in litigation is a tortuous act.

Mr. Justice Hawkins: That point has never been made before this moment. It is a point, no doubt, you are entitled to raise, but if so, I must give Mr. Jelf an opportunity of considering it.

Mr. Walton thought he had indicated the point in his opening.

Mr. Jelf: I say this point does not arise at all. It is not raised on the pleadings, and there is no evidence at all to support it.

Mr. Justice Hawkins: I don't want to discuss this new point at the present moment.

Mr. Walton: It is really a subordinate point, but it is an illustration of the evils of maintenance.

Mr. Justice Hawkins: The law is very clear. In almost all the old dicta upon the subject, maintenance is stated to promote strife, and stir up litigation without reasonable ground. It seems in this

case to come to this: the alleged libel itself is upon Dr. Tibbits, and the action can only be brought for the purpose of clearing his character. His character is attacked through the medium of these electric belts, and in order to vindicate himself, he must show that these belts are all that they are described to be. Mr. Walton upon that says that a man can not make out of that anything like such an interest as would prevent the law of maintenance from applying.

Mr. Jelf: I say that in this case nothing could be closer than the connection of Mr. Harness and Dr. Tibbits with regard to the real subject matter of the action, the merits or demerits of the electric belts.

Mr. Justice Hawkins: The matter is really one of great general importance, and I think it will be better if I give my judgment in detail. What I propose to do is to take a little time to consider and put upon paper the conclusions I arrive at.

City of London Electric Lighting Company, Limited *v.* United States Land and Investment Company.

The plaintiffs summoned the defendants at the Guildhall last week to show cause why they should not pay £5 9s. 7d. for the supply of electric current and rental of meter. The money was ordered to be paid, with £1 1s. costs.

Elmore's Wire Manufacturing Company.

In the Queen's Bench Division, on Monday, Mr. Justice Cave and Mr. Justice Collins gave judgment in an application made on Friday in the matter of A. T. Ashwell, solicitor, for an order directing taxation of his bill of costs against the Elmore Wire Manufacturing Company, Limited. The application had been refused by the Judge in Chambers on the ground that the bill had been paid.

Mr. Justice Cave, in giving judgment, said that looking at all the circumstances the proper conclusion appeared to be that the payment of £500 was not a settlement of the bill for £428, the balance going on account of the other bill, but a payment generally on account. He was not satisfied that the items complained of in the bill would amount to "special circumstances," which would justify the Court in directing taxation if there had been a settlement. No doubt a good many of the allegations of undue charges had been fairly explained away in the affidavits, although there were one or two items which it was reasonable to suppose might be reduced by the Taxing Master. Further, there were indications in the bill itself that it had been hastily prepared, and admittedly one or two items had been wrongly inserted. Under these circumstances the Court thought the best plan would be to send the bill for taxation, the costs of the present application to abide the result of the taxation.

The Edison-Bell Phonograph Corporation *v.* Smith and Young.

The Master of the Rolls (Lord Esher) and Lords Justices Kay and A. L. Smith on Wednesday commenced the hearing of an appeal by the defendants in this action from a judgment of Mr. Justice Wright, after hearing the case in February last, holding that they had infringed Mr. Edison's patent of 1889, No. 19,953, relating to phonographs.

Mr. Bousfield, Q.C., with Mr. Lewis Edmunds, represented the appellants.

Mr. Bousfield having addressed the Court, the argument was adjourned till yesterday.

BUSINESS NOTICES, &c.

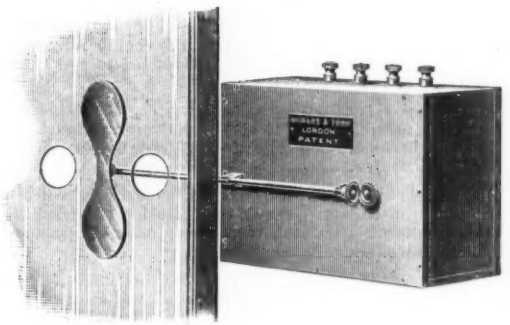
Electric Light at Bolton.—The Electrical Engineer last week submitted an estimate and cost of extension of the electric mains into Newport Street, and the Electricity Committee resolved that the works requisite for such extension be carried out. The tender of Messrs. Siemens Brothers for the supply and laying of the cables for the extension was accepted, and the Chairman was authorised to arrange for the construction of an additional transformer chamber at the corner of Great Moor Street and Newport Street. A scheme prepared by the electrical engineer for carrying into effect a system of supplying electric fittings on the hire purchase system was adopted.

Electric Lighting in Burnley District.—Messrs. E. H. Berry & Pope are now installing the electric light in Messrs. R. Thompson & Sons mill at Padiham, where they are fixing 270 lights; they are also fixing 80 lights for Messrs. N. Smallpage & Sons, at Kelbrook, near Colne, as well as fitting up the premises of the Union Club in Burnley. They are also busy with telephone work.

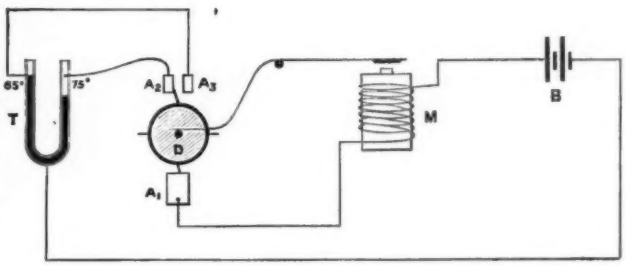
College Electric Lighting.—Bristol University College is shortly to be lighted by electricity, the installation to consist of a dynamo and 200 incandescent lamps. The contract has been let to Messrs. F. W. Ball & Co., of Unity Street, Bristol, who have carried out similar work at the Cathedral, the Council House, and other important buildings.

Electric Light at Dewsbury.—Messrs. Becker Bros., of Bradford Road, are having their premises lighted by electricity. Mr. A. Richmond Turner is carrying out the work; in all there will be 40 16-C.P. incandescent, and 1 500-C.P. arc lamps. Current will be taken from the corporation mains, when ready.

New System of Ventilation for Buildings.—A simple method of ventilation has long been needed, and the "Westbroode" thermo-electric ventilating apparatus, brought out and manufactured by Messrs. Hodges & Todd, provides a simple means of ventilation, combining both cheapness and efficiency, and, at the same time, is quite independent of personal supervision, being automatic in action. The apparatus consists of one or more valves or air regulators, electri-



cally controlled by means of a thermostat or thermometer, adjustable to certain pre-determined degrees of heat or cold, and the action is as follows:—Assuming that the temperature of the building or room is required to be kept, say, between 65° and 75° F., an electro-magnet, M, is placed in circuit with a battery, B, and a revolving drum, D, which is rotated by a strong spring, and makes circuit between the



bottom contact, A_1, and the two top contacts, A_2, A_3, alternately; on the temperature rising to 75°, the contact is made and circuit completed through A_2. The electro-magnet attracts armature and allows drum to rotate a quarter of a revolution; this opens the ventilator and cools the room. As soon as the drum begins to revolve the circuit is broken, and the battery is not again put into use until the temperature falls to the 65° point, when contact is again made and circuit completed through the other spring, A_3; the drum then rotates, and closes the ventilator. This action is repeated every time either limit is reached. The great feature in this invention is that by using a thermostat the apparatus can be adjusted to work at any desired variation of temperature; a variation of 2° F. will work it, also the electrical contact being momentary, only a very minute amount of current is used, considerably less than that required to ring an ordinary electric bell. This system of ventilation by having the air shafts electrically controlled is of inestimable value in hospitals, conservatories, public buildings, &c., and in all places where it is necessary to keep the temperature within certain points. The apparatus can be fitted to any existing air shafts or ventilators at a nominal expense, and once fixed can be left to do its work efficiently and reliably, with only the smallest amount of attention.

Ullathorne & Hartley.—This firm has secured the order for lighting up the Theatre Royal and Opera House, Bradford, with about 500 lights; the Self-Help Co-operative Society, Ravensthorpe, consisting of Tangye's 12 H.P. gas engine, dynamo, 20 arc and about 150 incandescent lights, amongst other large installation work.

Church Lighting.—For the lighting of the Leeds Parish Church, the plans and specifications have been prepared by Messrs. Shepherd & Watney, and the tender of Messrs. Laing, Wharton & Down accepted for carrying out the work. The total cost is said to be about £500.

Electric Wiring.—Messrs. Mavor & Coulson, for whom Mr. H. T. Barnett, of 53, Victoria Street, Westminster, was recently appointed agent for the southern district, have wired the offices of the London Electrical Goods Agency on their "C. C. concentric system."

Electric Light at Kensington.—The London County Council have given permission to the Kensington and Knightsbridge Electric Lighting Company to lay mains along and across New Street, Brompton Road.

Ipswich and Electric Lighting.—Prof. Kennedy has been elected consulting engineer for the local electric lighting scheme. Application for a provisional order will be made in the coming session.

Electric Light at Belfast.—The Corporation intend charging 7d. per unit for current. The tender of Messrs. M'Laughlin and Harvey for the erection of the new central station in Chapel Lane has been accepted.

The Derby.—The result of the Derby was transmitted by the Direct U. S. Company's cable, and delivered in New York to the News agencies at 10.22¼ a.m., almost simultaneously with the time the news reached London.

Electric Light at Chelmsford.—The Essex Standing Joint Committee have decided to light the county room by electricity. Messrs. Crompton have been instructed to carry out the work at a cost of £98 10s.

Personal.—Mr. Ernest Scott, M.I.E.E., recently on the staff of the Brush Electrical Engineering Company, has been appointed chief in the drawing office of the Electric Construction Company, Wolverhampton.

Change of Address.—The St. Martin's Electrical Manufacturing Company, Limited, during the extension of their business premises, have taken offices at 6, Adam Street, Adelphi, Strand, where all communications are to be addressed.

Colliery Electric Lighting.—Messrs. Hewes & Geary, of Church Gresley and Coalville, have secured the contract for the electric lighting of the Cadley Hill Colliery, Burton.

Electric Light in Water Works.—The Kinnaber Water Works, Montrose, were last week lighted by electricity for the first time. A Pelton water-wheel supplies the motive power to a 50-volt dynamo.

Hotel Electric Lighting.—Current was turned on at the Forsyth Hotel, Aberdeen, last week. The work connected with the installation was carried out by Mr. A. G. Emslie.

Electric Organ.—A new electric organ on the Hope-Jones system has lately been fitted up at Balruddery. The opening ceremony is to be performed to-morrow by Dr. Peace, of Glasgow.

Hotel Electric Lighting.—Messrs. Rashleigh Phipps and Co. have received the contract for the lighting of the Norfolk Hotel, Surrey Street, Strand, for 425 lights of 16 C.P.

CONTRACTS OPEN.

Ayr.—June 23rd. For the supply and erection of certain electric lighting plant, for the Local Authority of the Burgh of Ayr: (Section A) boiler house plant, including boilers and fittings, mechanical stokers and motor, forced draught apparatus, economiser, feed pump, injector, water tank, steam, feed, blow-off, and sundry pipes and valves; (B) engine house plant, including steam alternators, steam dynamos, independent condenser, exhaust pipes, oil filter, fittings, &c.; (C) switchboard and instruments; (D) underground work, including cables, culverts, brick chambers, and trenching; (E) transformers and boxes; (F) arc lamps and posts; (G) meters; (H) overhead crane. Particulars may be obtained at the offices of Mr. Robert Hammond, consulting engineer to the Corporation, Ormond House, Great Trinity Lane, London, E.C.

Mansfield.—June 12th. For the erection of a line of poles and overhead wires for the automatic indicating apparatus and telephones between the Rainworth pumping station and the waterworks manager's office at the gasworks, Mansfield, for the Waterworks Committee of the Mansfield Corporation. Further particulars from Mr. George Hodson, M.I.C.E., Bank Chambers, Loughborough.

Newcastle-upon-Tyne.—June 22nd. For telephonic apparatus for communication with the workhouse for the guardians. Further particulars from Mr. John W. Gibson, clerk to the guardians, Union Offices, Pilgrim Street, Newcastle-upon-Tyne.

Oswestry.—June 16th. The directors of the Oswestry Electric Lighting and Power Company, Limited, invite tenders for engines, boilers, dynamos, switchboards, cables and conduits for a central station and installation at Oswestry, Salop.

NOTES.

A New Patent.—In our list of "New Patents," that one numbered 10,052 will doubtless be a subject of amusement to some of our readers.

The World's Fair Great Search Light.—A Reuter's telegram from New York states that a great search light, constructed in France, which was exhibited at the Chicago World's Fair, has been erected at Sandy Hook, and was lit for the first time on Monday night. It is said to be of 194,000,000 candle-power.

Weston-super-Mare Electric Lighting.—The Electric Lighting Committee have appointed Mr. F. H. Medhurst, of Victoria Street, S.W., consulting engineer in connection with their electric lighting, electric tramway, and dust destructor scheme, to which we referred last week.

Derry Electric Lighting.—The Lighting Committee last week had a very lengthy discussion regarding the taking over of the electric lighting works from the contractors. The chief point giving rise to disagreement appears to have been the testing of the engines. Reports on this, however, were read, and ultimately it was resolved, by 11 votes to 8, to take over the works, and appoint a sub-committee to order the extinguishing of such lamps as are not required.

The Institution of Civil Engineers.—Among the awards made for original communications submitted during the past session were the following:—Telford Medals and Telford Premiums to James Henry Greathead, M.Inst.C.E., and Francis Fox, M.Inst.C.E. (of Westminster), for their joint paper on "The Liverpool Overhead Railway." A George Stephenson Medal and a Telford Premium to Thomas Parker, M.Inst.C.E. (of Wolverhampton), for his paper on "The Electrical Equipment of the Liverpool Overhead Railway."

The Institute of Electrical Engineers Conversazione.—Among those present at the conversazione on Thursday evening last week, to meet the president, Mr. A. Siemens and Mrs. Siemens, were Sir Frederick Abel, Prof. W. Grylls Adams, Dr. H. E. Armstrong, Prof. W. E. Ayrton, Sir Benjamin Baker, Sir Frederick Bramwell, Sir. J. Crichton-Browne, Mr. R. E. Crompton, Prof. William Crookes, Mr. Latimer Clark, Sir John Evans, Mr. S. Z. de Ferranti, Dr. J. A. Fleming, Prof. G. Carey Foster, Mr. C. Hawkesley, Dr. John Hopkinson, Prof. D. E. Hughes, Sir R. Hunter, Prof. A. B. W. Kennedy, Admiral Kinahan, Prof. O. J. Lodge, Sir Henry Mance, Prof. John Perry, Mr. W. H. Preece, C.B., the Earl Russell, Sir David Salomons, Sir E. M. Shaw, Mr. C. E. Spagnoletti, Prof. S. P. Thompson, Gen. C. E. Webber, Mr. Swinburne, and Sir H. Trueman Wood.

Death of Mr. Thomas Eccleston Gibb.—All our readers who knew Mr. Thomas Eccleston Gibb, the clerk to the St. Pancras Vestry, will regret to hear of his death. It can be safely said that no municipal officer ever worked so hard for electric lighting as did Mr. Gibb, and to his exertions is due in a great measure the electric lighting station owned by the vestry. But in all matters relating to electricity he took the greatest interest, and we knew of no man who could better interpret the Acts relating to electric lighting. Mr. Gibb was elected an Alderman by the first County Council, and represented South Pancras in the House of Commons in the short Parliament of 1886. He had the reputation of being one of the greatest authorities on the intricate laws relating to municipal matters.

The Great Northern Telegraph Company.—A despatch from Copenhagen states that Friday last being the occasion of the twenty-fifth anniversary of the foundation of this company, various festivities were held there. The event was also commemorated wherever the company has stations. The London staff were entertained at dinner at Seyd's Hotel, and a most enjoyable evening was spent, Mr. Nielsen, Commodore Svenson, and Mr. Tietgen being present. On Friday evening, June 1st, a large and distinguished company dined at the Savoy Hotel, among those present being the Danish Minister, the Swedish and Norwegian Minister, Sir John Pender, Mr. C. G. Lamb, and Count Ahlefeldt-Laurvig. Various toasts were enthusiastically drunk, and speeches made by the Danish Minister, Mr. Nielsen, Mr. Lamb, and Sir John Pender. The chairman and managing director have each received valuable presents from the board of directors and from the staff. In order to mark their appreciation of their employés' services, the directors have given to every one of them a present equal to from one to six months' salary, according to length of service. Clerks, messengers, coolies, and housekeepers have all had their share in this distribution, which cannot fail to effect the most harmonious working of their system.

Eccles and Electric Lighting.—Dr. J. Hopkinson has submitted his report regarding electric lighting the district.

Royal Society.—The annual *conversazione* will be held on Wednesday next, June 13th.

Church Lighting.—The electric light has lately been fitted in Adelaide Street Church, Blackburn. The total lamps installed represent 1,758 C.P.

Cricket.—A cricket club has been formed by the employés of the Westminster Electric Supply Corporation, with Mr. W. A. Pearman as hon. sec., and will for the rest of the season play on the Raynes Park Ground.

Battersea Vestry and Electric Motors.—As the Vestry consider their horses a great expense, they have instructed a committee to discuss whether electric motors can be substituted for them.

Electric Lighting at Bridlington.—It has been resolved to light the sea front from the north end of Prince's Parade to the north end of the Beaconsfield sea wall by electricity, at an estimated cost of £275. Seven 2,000 C.P. arc lamps will be used.

Electric Lighting at Birkenhead.—It is intended that application be made to the Local Government Board for sanction to the borrowing by the Council of the sum of £18,424 for the purpose of constructing a central electrical station in Bentinck Street.

Obituary.—We regret to announce the death of Vice-Admiral George William Preedy, which occurred at his residence, Park House, Budleigh Salterton, Devonshire, on Wednesday last week, at the age of 77. In 1858 he commanded the *Agamemnon* when it was employed in laying the first Atlantic cable, and received the Companionship of the Bath (civil division) for this service, and also a gold medal from the Chamber of Commerce and citizens of New York, and an illuminated address with gold box from the City of New York.

Overheard at the Conversazione.—"See yonder tall, thin, pale, bespectacled young man talking so eagerly and earnestly with Dr. Hopkennedyson: that must be William, who discourses so learnedly (ahem!) concerning institutions and meetings in the issues of a sheet of which gratuitous copies are often sent to me. How pleasant it is to see and meet with those who are thought great, whether by others, or *par excellence*—by themselves." "Wh—a—a—t! you mean to say that you really thought that lanky length of concentrated philosophy and wisdom was the preternaturally precocious youth who writes of what he comprehends not in that bilious-looking jaundiced journal! Why you don't know enough to come in out of the wet. 'William' is only a plum-name—as Mrs. Malaprop has it: William's proper name is Robert, though they say that this is but a 'given' name, after the American fashion; they tried to christen him when young, but it didn't take, being unlike the measles or vaccination. Robert finds no end of fun in posing as the personification of youthful innocence, whilst there is also considerable profit in assuming an *alias*, because this allows of great self-glorification, coupled with endless chances of running the other fellows down. My dear sir, the next time you come up from the country to find a wolf in sheep's clothing, you'll do it more quickly if you also listen, than if you merely look."

NEW COMPANIES REGISTERED.

E. Wallace & Co., Limited (41,218).—This company was registered on the 24th ult. with a capital of £1,000 in £1 shares, to act as agents for manufacturers or producers of all classes of goods, and in particular of chemical, mechanical, or electrical goods and appliances, or for firms dealing in, or making, goods appertaining to mechanical or electric uses; and to sell all kinds of electrical, surgical, and scientific instruments. The subscribers (with one share each) are:—A. R. Green, Kinnear's Hotel, Cheapside, E.C., manager; M. Smith, 58, Bread Street, E.C., electrical engineer; W. H. Berry, 58, Bread Street, E.C., electrician; W. Young, 58, Bread Street, E.C., accountant; W. Hayward, 18-19, Giltspur Street, E.C., carver, &c.; W. R. Long, 88, Queen Victoria Street, E.C., accountant; H. W. Andrew, Frobisher Road, Hornsey, N., shorthand writer. Registered without articles of association by E. Wangenheim, 30, Newgate Street, E.C.

Cowper Coles Galvanising Syndicate, Limited (41,223).—This company was registered on the 25th ult. with a capital of £2,000 in £1 shares (500 "A" and 1,500 "B"), to enter into a certain agreement, and to carry on the business of electricians, electrical engineers, electro-metallurgists, engineers, and galvanisers. The subscribers (with one share each) are:—L. W. N. Hickley, 10, King's Bench Walk, E.C., solicitor; T. H. Balding, Parson's Green, solicitor's clerk; A. H. Roe, Stamford Hill, shorthand clerk; E. Garcke, 21, Priory Road, W., director; B. W. Walker, 1, Queen's Place, Southsea, captain R.N.; H. Elmunds, C.E., Upper Tulse Hill, S.W.; E. J. Pilcher, Pimlico, shorthand clerk. The first directors are:—Sir B. W. Walker, Bart., and W. N. Hickley, H. Edmunds, and E. Garcke; qualification, one share; remuneration not stated. Registered office, 39, Victoria Street, Westminster, S.W.

Binns Gas and Oil Engine Company, Limited (41,231).—This company was registered on the 28th ult. with a capital of £2,000 in £1 shares, to acquire the goodwill of the business carried on at Halifax, Yorks, under the firm of Binns & Co., and to carry on the business of gas, mechanical, and electrical engineers. The subscribers (with one share each) are:—Joseph Pickles Binns, 75, High Street, Luddenden, engineer; Susey Binns, 75, High Street, Luddenden, married woman; H. G. Binns, 30, Milton Terrace, Halifax, engineer; M. M. Binns, 30, Milton Terrace, Halifax, married woman; J. Horsfall, Currfield, Luddenden, widow; F. W. Thompson, Luddenden, engineer; A. Yates, Luddenden, engineer; H. Yates, Luddenden, married woman. The first directors are:—J. P. Binns, H. G. Binns, F. W. Thompson, A. Yates; qualification, £100; remuneration not stated. Registered by J. B. Holroyde, Halifax, solicitor.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

A. Ransome & Co., Limited (37,861).—This company's annual return, filed on April 27th, shows that out of a nominal capital of £59,000 in £10 shares, the whole of the shares have been taken up, and that the full amount has been called on 307. The total received is £3,070, and £55,930 has been agreed to be considered as paid.

Holloway Electricity Supply Company, Limited (36,725).—This company's last return shows that out of a nominal capital of £2,000 in £10 shares, only seven shares have been taken up. Nothing has been paid.

Hope-Jones Electric Organ Company, Limited (36,737).—The registered office of this company, which was formerly at 4, Huggin Lane, E.C., is now situated at 55 and 57, Argyle Street, Birkenhead, Cheshire.

House-to-House Electric Light Supply Company, Limited (25,913).—The annual return of this company was filed at Somerset House April 14th last. It shows that out of a nominal capital of £350,000 in 57,900 ordinary, 100 founders', and 12,000 preference shares all of £5 each; 8,322 ordinary, the whole of the founders', and 5,000 preference shares have been taken up, and that the full amount has been called on each. A sum of £61,610 has been received, and £5,500 is still outstanding.

Lancashire and Cheshire House-to-House Electricity Company, Limited (29,227).—This company filed its annual return on the 9th ult. It appears that only 107 shares out of a nominal capital of £100,000 in 19,900 ordinary and 100 founders' shares, all of £5 each, have been taken up. Nothing has been received, and £500 has been agreed to be considered as paid.

Indo-European Telegraph Company, Limited (3,953).—This company's annual return, filed on May 18th last, shows that out of a nominal capital of £450,000 in £25 shares, 17,000 shares have been taken up, and that the full amount has been called on each. The sum received in response to calls is £425,000.

Liverpool Electric Supply Company, Limited (17,760).—On April 18th last this company filed its annual return, which shows that out of a nominal capital of £300,000 in £5 shares, 45,000 shares have been taken up, and that the full amount has been called on each. A sum of £220,985 10s. has been received, and there is £4,014 10s. outstanding.

Lancashire and Yorkshire Electric Lighting Company, Limited (17,486).—The annual return of this company, filed on March 22nd last, shows that, out of a nominal capital of £100,000 in £5 shares, 127 shares have been taken up, and that £2 10s. has been called on each of these. A sum of £315 has been received, and there is £2 10s. outstanding.

India-Rubber, Gutta-Percha and Telegraph Works Company, Limited (1,122 C).—This company's latest annual return, filed on May 8th, shows that, out of a nominal capital of £812,000 in £10 shares, 50,000 shares have been taken up, and that the full amount has been called and duly paid on each. The total received is, therefore, £500,000.

Liverpool House-to-House Electricity Company, Limited (29,228).—This company's annual return filed on the 9th ult. shows that 107 shares out of a nominal capital of £100,000 in £5 shares have been taken up. A sum of £500 has been agreed to be considered as paid; and nothing has been received.

James Simpson & Company, Limited (36,797).—This company filed its yearly return on the 22nd ult., which shows that out of a nominal capital of £250,000 in 7,351 preference and 15,017 ordinary shares of £10 each, the whole of these shares have been taken up. A sum of £70 has been received on account of seven ordinary shares; and £223,610 has been agreed to be considered as paid.

CITY NOTES.

Gülcher (New) Electric Light and Power Company, Limited.

On Monday last about twenty shareholders attended at Winchester House to hear Mr. De Castro's statement regarding the position of the company, to pass the accounts to June 31st, 1893, and pass resolutions winding up the company voluntarily, and to appoint a liquidator. Some very lengthy observations were made by Mr. De Castro, who presided, and, considering the state of affairs, the proceedings were milder than might have been expected. The opposition was as usual led by Major Cotton, who was only supported by two or three other shareholders, a large portion of those present abstaining from voting either way. The report and accounts were adopted, and the Chairman submitted a further statement of the position of the company to May 31st, 1894. The usual winding-up resolution was passed, and Mr. C. F. Kemp (of Kemp, Ford & Co., the company's auditors), was appointed liquidator.

The Chairman, in the course of his remarks, stated that the career of the company for the past 11 years had been one continuous struggle to succeed. The net loss of £15,822 was doubtless at first sight very startling to the shareholders. As a study of the profit and loss account would explain the loss better than anything else, he would refer to that first. In the manufacturing account the stock on July 1st, 1892, was valued at £17,102 17s. 3d.; the plant the same year was valued at £6,732 4s. 8d., so that really in their balance-sheet of 1892 the stock and plant represented £23,835. The *present* valuation is put down as £12,500, so that upon that account there was an apparent depreciation of the stock of £11,335, or, in other words, their late manager wrote off 50 per cent. of the stock and plant last year. The loss of the year's trading amounted to £6,400, and that loss was made under every possible advantage of working, except that of having plenty of capital. They had a very large and profitable order from New Zealand, which they thought would pull the company round, but he was now satisfied that, with the present expenses, and with the present capital, the Gülcher Company could not possibly succeed. Some details were given as to the standing expenses. The stock account showed £17,000, and the purchases £14,600, and there were, further, the expenses of carrying on the business. Rent, rates, and taxes were £679; superintendence included £500 to himself (Mr. De Castro), £700 to the general manager, £200 to the secretary, and other smaller sums to members of the staff. Bad debts were £1,421. There were also law costs and other small items. On the other side there were sales and hires of dynamos, £24,368. Of that £24,368, very nearly £20,000 was due to the New Zealand contract, which paid well; it was a good contract, but showed that their sales in this country had dwindled down to less than £5,000. That was the most serious matter they had had to face, because it was quite clear that in electrical matters, now, it was no good the small companies trying to compete for central station work. The consignment to the New Zealand branch was £1,814 for plant and stuff sent out for sale there; when that was sold the profit would come into the New Zealand accounts, and therefore could not be put down as sales now. Stock in hand had been written down from £12,905—about £4,000 for depreciation—which was about 30 per cent., the manager considering that a great deal of it was obsolete. He wrote down plant also, and that had accounted for the calamitous appearance of the balance-sheet. Respecting the present position of the company, they had power given to them at the last meeting to borrow £10,000. £5,000 was borrowed upon the debentures in August. The first debenture holders were £8,000, and they had borrowed £5,000 on second charge; that was to say, they had borrowed £5,000 from the bankers, charging the second debentures with it and the uncalled capital. Some of the directors had advanced to the company to pay off the debts, £5,800; there were also rent, rates, and taxes in arrears, amounting to about £400 to the end of June, 1894. The only unsecured creditors of the company remaining amounted to about £1,300. The total liabilities of the company were £20,845, exclusive of its shares. The assets of the company were put down at the valuation mentioned, *i.e.*, £12,500. They had cash debts amounting together to £4,900, and uncalled capital and calls in arrear, £5,600, so that there would be an apparent surplus of assets over liabilities of £1,500 cash, but in addition there were shares in the New Zealand Electrical Syndicate, £21,000 or £22,000. They hoped to have a substantial distribution among the shareholders from the New Zealand holding. He (the speaker) had made arrangements for the sale of the stock and plant for £12,500, taken as to £5,700 in cash and £6,800 in shares of one of the large companies. He had also arranged with some of the debenture holders that they would take £5,000 in cash and £3,000 in debentures in that particular company. He had been able to find money to carry out any unfinished contracts. He had also provided for their most important creditor the rent, £400. Nothing then remained but the £5,000 loan of the bank, and the £6,000 due to the directors. They first meant to pay their creditors up to the hilt. They had decided to postpone the £5,900 which they had advanced on a third charge until the £1,300 creditors still unpaid had been settled with. There would therefore be no creditors upon the company except themselves, as directors, until the call had been paid and the bankers been discharged.

The auditors' report was read by the Secretary, and some discussion having taken place, the resolution was carried with three dissentients.

An extraordinary general meeting was then held, and after the Chairman had again addressed the meeting, the winding-up resolution was agreed to, and the liquidator appointed as stated above.

The Swan United Electric Light Company, Limited.—An extraordinary general meeting of this company will be held at the Cannon Street Hotel, Cannon Street, E.C., on Thursday, the 14th inst., at 12 o'clock noon, to consider, and if approved, to pass the following resolution, which, if passed by the required majority, will be submitted to a second meeting to be hereafter convened for confirmation as a special resolution, viz.:—"That the Swan United Electric Light Company, Limited, be wound up voluntarily, and that Henry Charles Gover, of 100, Queen Victoria Street, in the City of Westminster, be, and he is hereby appointed liquidator for the purpose of such winding up, and that the liquidator be, and he is hereby authorised to carry into effect upon the terms of a provisional agreement between the two companies, dated June 5th (subject to any modification), a sale of the company's undertaking to the Edison and Swan United Electric Light Company, Limited, for debenture stock of that company to be distributed among the members of this company."

The Electric and General Investment Company, Limited.—The directors have decided to recommend to the shareholders the payment of a further dividend upon the ordinary shares at the rate of 40 per cent. per annum for the six months ended May 31st last (making with the interim dividend of 10 per cent already paid, 25 per cent. for the year), and a dividend on the founders shares of £30 per share for the year.

Telegraph Manufacturing Company.—The annua ordinary meeting of shareholders of this company was held on the 4th inst., and the same dividend as last year was declared, viz., 5 per cent., and in addition a bonus of 2½ per cent.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending June 3rd, 1894, amounted to £869; week ending June 4th, 1893, £914; decrease, £45; total receipts for half-year, 1894, £20,012; corresponding period, 1893, £19,493; increase, £519.

The Cuba Submarine Telegraph Company. The estimated traffic receipts for the month of May were £3,550; as compared with £3,712 in the corresponding month of last year.

The Direct Spanish Telegraph Company, Limited. The estimated receipts for the month of May, 1894, amounted to £1,594, against £1,866 in the corresponding period of last year.

The Great Northern Telegraph Company. The traffic receipts in May, 1894, were £22,800; January 1st to May 31st, 1894, £105,800; corresponding months, 1893, £108,000; corresponding month, 1892, £104,800.

The Western and Brasilian Telegraph Company, Limited. The receipts for the week ending June 1st, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brasilian Telegraph Company, Limited, were £2,637.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1891.	1892.	1893.	Closing Quotation, May 30th.	Closing Quotation, June 6th.	Business done during week ended June 6th, 1894. Highest.	Lowest.
184,500£	African Direct Teleg., Ltd., 4 % Deb.	100	...	...	...	102 —105	102 —105	...	...
1,134,640£	Anglo-American Teleg., Ltd.	Stock	£2 12s.	£2 15s.	£2 11s.	41 — 43	43 — 45	...	...
2,932,680£	Do. do. 6 % Pref.	Stock	£5 5s	£5 10s	£5 2s.	79 — 80	82 — 83	82¼	79½
2,932,680£	Do. do. Defd.	Stock	...	...	...	7½ — 7¾	7¾ — 8¼	8	7⅞
130,000	Brazilian Submarine Teleg., Ltd.	10	8 % §	6⅛ % §	6⅛ % §	12 — 12½	12 — 12½	12½	12 1/16
18,700£	Do. do. 5 % Bonds	100	...	...	...	100 —103	100 —103	...	...
75,000£	Do. do. 5 %, repayable June 1906	100	...	...	...	108 —112	108 —112	...	...
44,000	Chili Telep., Ltd., Nos. 1 to 40,000	5	... §	10%‖ §	... §	1½ — 2½	1½ — 2½	...	...
10,000,000$	Commercial Cable Co.	$100	7 %	7 %	7 %	140 —145	140 —145	144	143½
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	3½% §	2 % §	... §	1/16 — 1/8	1/16 — 1/8	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	12 — 13	12 — 13	...	...
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	18 — 19	18 — 19	18 15/16	18¼
12,931	Direct Spanish Teleg., Ltd., £4 paid	5	4½%	4 %	4 %	2¾ — 3¼	3⅜ — 4¼	...	...
6,000	Do. do. 10 % Pref.	5	10 %	10 %	...	9 — 9½	9 — 9½	...	...
60,710	Direct United States Cable, Ltd., 1877	20	3½% §	3½% §	...	9¼ — 10	9¾ — 10¼	10	9¾
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½% §	6½% §	...	14¾ — 15	14¼ — 15⅛	15 1/16	15
70,000	Do. 6 % Pref.	10	6 % §	6 % §	...	15¾ — 16¼	15¾ — 16¼	16⅛	16 1/16
105,900£	Do. 5 % Debs., repay. August, 1899	100	...	...	...	107 —110	107 —110	...	...
1,294,100£	Do. 4 % Mort. Deb.	Stock	...	...	...	113 —116	113 —116	115	113¼
250,000	Eastern Extension, Australasia and China Teleg., Ltd. ...	10	7 %	7 %	7 %	15½ — 15¾	15½ — 15¾	15¾	15½
62,700£	Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	...	...	...	104 —107	104 —107	...	...
222,800£	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	...	...	...	104 —107	104 —107	...	...
320,000£	Do. 4 % Deb. Stock	Stock	...	...	...	114 —117	114 —117	116	...
95,100£	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	...	...	...	104 —107	104 —107	106⅞	...
129,100£	Do. do. do. to bearer, 2,344 to 5,500	...	...	...	...	104 —107	104 —107	...	...
300,000£	Do. 4 % Mort. Debs. Nos. 1 to 2,016, red. 1909	100	...	...	...	104 —107	104 —107	...	...
200,000£	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	...	...	...	106 —109%	106 —109%	...	...
180,227	Globe Telegraph and Trust, Ltd.	10	5⅛% §	4⅞% §	4⅝% §	8¾ — 9	8¾ — 9⅛	9 1/16	8⅞
180,042	Do. do. 6 % Pref.	10	6 % §	6 % §	6 % §	15¼ — 15½	15¼ — 15½	15½	15 5/16
150,000	Great Northern Teleg. Company of Copenhagen	10	8⅗% §	8⅗% §	8⅗%	21 — 21½	21 — 21½	...	...
200,000£	Do. do. do. 5 % Debs.	100	...	...	...	104 —107	104 —107	...	...
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	...	43 — 45	43 — 45	44¾	44½
37,548	London Platino-Brazilian Teleg., Ltd.	10	...	...	...	4 — 6	4 — 6	...	...
100,000£	Do. do. 6 % Debs.	100	...	...	...	106 —109	106 —109	...	...
15,000	Monte Video Teleph. Co., Ord., 1 to 15,000	5	...	...	...	⅛ — 1⅛	⅛ — 1⅛	...	...
28,000	Do. do. 6 % Pref., 1 to 28,000	5	...	...	...	1 — 2	1 — 2	...	...
484,597	National Teleph., Ltd., 1 to 438,984	5	6 % §	5 % §	...	4⅞ — 5⅛	4⅞ — 5⅛	5 1/16	4 15/16
15,000	Do. 6 % Cum. 1st Pref.	10	...	...	...	15 — 16	15 — 16	15 1/16	15
15,000	Do. 6 % Cum. 2nd Pref.	10	...	...	...	14½ — 15½	14½ — 15½	...	...
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 90,950	5	...	...	...	5⅛ — 5⅜	5⅛ — 5⅜	5⅜	5 5/16
925,017£	Do. 4½ % Deb. Stock Prov. Certs. ...	...	...	...	...	114 —116	115 —117	115½	...
48,800	New Teleph., Ltd., 25,901 to 74,700; £4 paid	10	...	...	...	... ...	... ...	...	...
171,504	Oriental Teleph. & Elec., Ltd., Nos. 1 to 171,504, fully paid	1	...	...	...	½ — ⅝	½ — ⅝	...	...
100,000£	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	...	...	...	102 —105	102 —105	...	...
11,839	Reuter's Ltd.	8	5 %	5 %	...	5½ — 6½	5 — 6	...	...
3,381	Submarine Cables Trust	Cert	...	...	...	112 —116	113 —118	...	...
58,000	United River Plate Teleph., Ltd.	5	...	...	...	1½ — 2	1½ — 2	...	...
146,370£	Do. do. 5 % Debs.	Stock	...	...	...	90 —100	90 —100	...	...
15,609	West African Teleg., Ltd., 7,501 to 23,109	10	4 %	..	...	3 — 5	3 — 5	...	...
249,900£	Do. do. do. 5 % Debs.	100	...	...	...	101 —104	101 —104	...	...
30,000	West Coast of America Teleg., Ltd.	10	...	...	...	2½ — 3	2½ — 3	...	...
150,000£	Do. do. do. 8 % Debs., repay. 1902	100	...	...	...	100 —105	100 —105	...	...
64,242	Western and Brazilian Teleg., Ltd.	15	4 %	2½%	...	7¼ — 7⅜xd	7¼ — 7⅜xd	7⅜	...
33,129	Do. do. do. 5 % Cum. Pref. ...	7½	...	...	...	6¼ — 6⅜xd	6¼ — 6⅜xd	...	...
33,129	Do. do. do. 5 % Def.	7½	3 %	...	...	2 — 2½	2 — 2½	2½	...
178,200£	Do. do. do. 6 % Debs. "A," 1910 ...	100	...	...	...	106 —109	106 —109	...	...
222,700£	Do. 6 % Mort. Debs., series "B," red. Feb. 1910	100	...	...	...	106 —109	106 —109	...	...
88,321	West India and Panama Teleg., Ltd.	10	¼%	¼%	...	1⅛ — 1⅜	1⅛ — 1⅜	1¼	...
34,563	Do. do. do. 6 % 1st Pref. ...	10	...	...	...	10¼ — 10⅜	10¼ — 10⅜	10⅜	10½
4,669	Do. do. do. 6 % 2nd Pref. ...	10	...	...	..	9 — 10	9 — 10	...	...
80,000£	Do. do. 5 % Debs. (1917) No. 1 to 1,000	100	...	...	...	109 —112	109 —112	...	...
$1,214,000	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds ...	$1000	...	...	...	110 —115	110 —115	...	...
169,000£	Do. do. 6 % Ster. Bonds.	100	...	...	...	100 —104	100 —104	...	...

ELECTRICITY SUPPLY COMPANIES.

20,510	Charing Cross and Strand Electy. Supply, 1 to 6, 215 to 718, and 10,001 to 30,000	5	...	5 %	4½%	4½ — 5½	4½ — 5½	...	...
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,000—180,000	10	...	...	...	12 — 13	12 — 13	12⅛	12
20,000	Do. do. 6 % Cum. Pref., 1 to 20,000	10	...	6 %	6 %	13½ — 14	13½ — 14	13 15/16	13¾
100,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) £75 paid	...	...	...	...	83 — 85	83 — 85	84⅜	...
19,900	*Electy. Supply Co. of Spain, 101 to 20,000...	5	...	...	...	... ...	... ...	...	...
45,000	†Liverpool Electric Supply, £4 10s. paid	5	4½%	5 %	5 %	6⅜ — 6½	6⅜ — 6½	...	...
49,900	*Metropolitan Electric Supply, Ltd., 6,101 to 50,000 ...	10	1 %	2 %	...	7½ — 8	8 — 8½	8½	...
100,000£	Do. 5% Deb., 1 to 10,000 in bonds of £10, £20, £40	...	...	...	...	108 – 111	107 —110 xd	...	...
6,452	Notting Hill Electric Lightg. Co., Ltd.	10	...	...	...	4½ — 5½	4½ — 5½	...	...
19,980	St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-18,780	5	8½%	7½%	4½%	6⅞ — 7¼	6⅞ — 7¼	...	...
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	8 — 8½	8 — 8½	8⅜	...
59,900	*Westminster Electric Supply Corp., Ord., 101 to 60,000 ...	5	...	3½%	4 %	6¼ — 6⅜	6¼ — 6⅜	6⅝	...

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

‡ Unless otherwise stated all shares are fully paid. ‖ Dividends paid in deferred share warrants, profits being used as capital.

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES.

Present Issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1891.	1892.	1893.	Closing Quotation, May 30th.	Closing Quotation, June 6th.	Business done during week ended June 6th, 1894. Highest.	Lowest.
90,000	Brush Elecl. Enging. Co., Ord., 1 to 90,000	3	...	6 % §	6 % §	2¾— 3	2⅞— 3	3	2⅛
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	...	6 % §	6 % §	2⅛— 2⅜	2⅛— 2⅜	2 5/16	2⅛
125,000/	Do. do. 4½ % Deb.	Stock	...	...	...	108 —111	108 —111	110½	...
630,000/	City and South London Railway	Stock	...	⅝%	⅝%	33 — 35	36 — 38	37½	35
20,000	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 20,000	5	7 % §	7 % §	7 % §	3 — 3½	3 — 3½	...	...
50,000/	Do. do. 5 % 1st Mort. Debs., 1—400 of £100, and "A" 1—200 of £50 each	...	...	...	...	95 —100	95 —100	...	...
120,000	Electric Construction, Ltd., 1 to 120,000	2	...	...	...	¼— ⅜	¼— ⅜	...	...
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ...	2	...	...	...	1¼— 1⅜	1¼— 1⅜	...	...
100,000	Elmore's French Patent Cop. Deposg., Ltd, 1 to 66,750 ...	2	*nil*	*nil*	*nil*	¼— ⅜	¼— ⅜	...	...
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil* ¶	*nil*	*nil*	1¼— 1½	1¼— 1½	1⅜	1¼
67,385	Elmore's Wire Mfg., Ltd., 1 to 67,385, issued at 1 pm. ...	2	*nil*	*nil*	*nil*	1 — 1¼	1 — 1¼	1 5/16	1⅛
20,000	Fowler-Waring Cables, Nos. 301 to 20,300	5	*nil* §	*nil* §	*nil* §	½— 1⅛	½— 1⅛	...	...
9,600/	Greenwood & Batley, Ltd., 7 % Cum. Pref., 1 to 9,600 ...	10	7 %	...	...	6½— 7½	6½— 7½	...	...
6,837	Henley's (W. T.) Telegraph Works, Ltd., Ord.	10	5 %	5 %	5 %	6½— 7½	6½— 7½	...	...
50,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	10	12½%	12½%	12½%	23 — 24	23 — 24	23⅝	23
200,000	Do. do. do. 4½ % Deb., 1896	100	...	...	...	103 —105	103 —105	103¾	...
37,500	†Liverpool Overhead Railway, Ord.	10	...	...	1 %	8⅝— 8¾	8 7/16— 8 9/16	8¾	...
6,295	† Do. do. Pref., £8 paid	10	...	...	...	12¾— 13¼	12¾— 13¼	...	...
78,949	Swan United Electric Light, Ltd., £3½ paid	5	11 % §	10 % §	7½% §	1¾— 2¼	2 — 2⅛	2 5/16	2 3/16
37,350	Telegraph Constn. and Maintce., Ltd.	12	20 %	15 %	20 %	39 — 41	39 — 41	40½	39¾
150,000/	Do. do. do. 5 % Bonds, red. 1894	100	...	...	...	104—107	104 —107	...	...

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50% for 1890.
Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.
CROMPTON & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0%§; 1891—7%§; 1890—8%§.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Birmingham Electric Supply Company, Ordinary of £5 (fully paid), 5¼—5⅝.
Electric Construction Corporation, 6 % Debentures, 87—92.
Electric and General Investment, shares of £5 (£1 paid), 1⅜—2¼.
Electricity Supply Corporation, Ordinary of £5, 5—5¼.
House-to-House Company (£5 paid), 1—1½.
Do. do. 7 % Preference, of £5, 5¼—5½.
Do. do. 6 % Debentures of £100, 101—103.
Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid) 4⅜—5¼; 1st Preference Cumulative 6 %, £5 (fully paid), 6¼—6⅞.
Liverpool Electric Supply, £5 (fully paid), 6½—6⅝.
Do. do. £3 10s. paid, 4½—4⅝.
London Electric Supply Corporation, £5 Ordinary, ⅞—1½.
Queen Anne's Mansions Lighting and Heating Company, 6 % £100 Debentures, 101—103.
Yorkshire House-to-House Electricity Company, £5 Ordinary Shares (£4 10s. paid), 4¼—4⅜.

Bank rate of discount, 2 per cent. (February 22nd, 1894).

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.

DISCUSSION ON MR. CROMPTON'S PAPER ON "THE COST OF ELECTRICAL ENERGY," May 24th.

(*Concluded from page* 646.)

Mr. PEACHE* said in Mr. Paxman's absence he would like to make one or two remarks concerning the Economic boiler which had been mentioned in the paper, and which Mr. Paxman had been making for over 30 years. The author had mentioned many good points of the boiler, but there was one recent improvement which he would like to point out. Diagrams had been put on the screen representing four views of the Economic boiler. The lower one in the right hand corner showed a section in plan, and from that it could be seen that the tubes were divided into two groups; they were close together at the back end of the boiler, and separated at the front end of the boiler by a space large enough for a man to get in, and there was also a space at the two sides of the back end of the boiler. That arrangement enabled the boiler to be entirely opened to internal examination for boiler inspection purposes, an advantage not shared by the ordinary semi-marine, locomotive or marine boilers. Another point of great importance in the Economic boiler was the combustion chamber at the back, which when heated to a high temperature efficiently provided for the consumption of otherwise unconsumed products, and enabled bituminous coal to be used without producing smoke. He thought the author intended Table III., which gave the boiler performances, chiefly as a basis for comparison for engineers in charge of central stations, in order that they might compare the results shown with the results obtained from their own boilers. The figures were very valuable used in that way, but they were less so when taken as a comparison of the boilers named, for, besides the efficiency of the boiler they had to take into consideration the efficiency of the stoker, and also the conditions under which a particular station was working. Therefore the table could hardly be taken as a comparison of the efficiencies of boilers. In Table IV., which gave the efficiency of sundry types of boilers, the last item but one, a semi-marine type of boiler, giving an evaporation of 12·2, was a Paxman Economic. In neither of the Tables, III. and IV., was there any determination given of the quantity of water carried over as water with the steam, and to that extent the figures were open to question. In the selection of a boiler one very important point was the cost for maintenance and repairs. There was only one instance given in the paper, that of the Kensington and Knightsbridge station, and the figures given there for the last four years' working, viz., 5½ per cent. per annum on their first cost, seemed, on the face of it, rather high. He was sorry to say he had not been able to get any figures from stations where Economic boilers were used, as the figures had not been kept separate. Mr. Paxman's experience with these boilers proved to him that the cost of repairs and maintenance amounted to very much less than the amount named above, and he regretted that he had not actual figures to support this statement.

Prof. KENNEDY,* taking the matter of coal first, said he was very pleased to inform Mr. Segundo that Mr. Grimshaw, at the Eccleston Place station, had already got down to 4¼ lbs. per unit generated for three months this year, and he was sure that was not an ideal result, because everybody could go much lower. He thought, perhaps, Mr. Crompton had put the matter a little too far down the scale, but that was merely a matter of opinion. He would just show how he thought they might perhaps make a more possible ideal than the noble one he had put before them. If they took the actual working time they could evaporate 10½ from and at, or, coming to the engines, 9½ lbs. per lb. of coal, if they took it that their stand-by coal was something like 8 per cent. of the rest, which was probable, and that they wanted, he regretted to say, something like 3 per cent. for their pumps and waste through the pistons, as was too often the case, and 5 per cent. condensation in the steam pipes, which a station must have, they got down to 8½ lbs. of steam getting to the engines per lb. of coal. Working that out on the basis, which of course was a very good one indeed, of 16 lbs. of water per I.H.P. and of 77 per cent. efficiency between the engine and dynamo at ¾-load, which was a very high figure at average working and of 90 per cent. of the units generated as sold, as a result they got down to 3·64 lbs. of coal per unit sold, or about 3¼ lbs. per unit generated. He hoped next time Mr. Crompton read a paper he would tell them that he could give two or three examples in which this was already got, and that, therefore, he was quite right in taking the possible standard as being considerably lower. Prof. Unwin had already dealt with the question of the value of north country coal. He would like to say that he believed it was more difficult to get the value out of such coal, although certainly with proper care the value could be got out of it; and he was sure it was much easier to stoke and feed the high quality Welsh coal than the almost equally high quality of coal to be obtained from the north. As to boilers, it might interest members if he mentioned that in Glasgow they would stand nothing whatever but marine types pure and simple; they used, of course, the cheapest kind of fuel they could get, a kind of char, an inferior type of coke from the gas works, which cost 4s. 6d. at the gas works and was certainly not worth more.

* Speakers marked with an asterisk have corrected their remarks.

That worked very well in the marine type if not stirred up too much, and with a very economical result in money and a very fair result in evaporation. He ought to say with regard to the calorific value of that coke, which Mr. Crompton had given in Table IX., that it should be marked "approximate," for although he gave it to Mr. Crompton as analysis of Glasgow coke, it was not taken at the time, and he could not say that the coke in the trial quoted had a value of 12,000 thermal units. He would not add more than a word or two to what Prof. Unwin had said about the Lancashire boiler. He had not got any such excellent trials as Prof. Unwin brought before them, a couple of 24-hour trials, but on one particular trial, lasting he believed ten hours, made on a plant of Easton & Anderson at Addington, in 1890, they did get for a particularly careful test an evaporation of 11·7 lbs. per lb. of carbon burnt without economisers and 12·4 with, a very high result. The boilers were, no doubt, somewhat underworked, only burning 6 lbs. of coal per square foot of grate. He believed such boilers could be made as economical as any other type if they received the treatment which they ought to receive, which, of course, was not the kind of treatment they gave to boilers of other types. Mr. Crompton had referred to the fact that certain figures were unknown to the works engineers themselves. He would again lay stress upon his belief that the economy of a station depended very much on the extent to which engineers measured what went out of it. He felt sure that this matter might be laid to heart by a good many folk who were rather careless in these things, and that they would find it pay them to set to work to measure everything they were doing. It was possible now to get, if not the extremest accuracy, at least as much accuracy as they observed in measuring their coal. With regard to the question of rope-driving, it might interest members to know that there were being conducted just now in Belgium, under the care of a large committee of Belgian engineers, a series of what he hoped would be some exhaustive and complete trials on this particular matter; that was to say, plant had been set up for the particular purpose of measuring the amount of power taken up by belts and ropes as apart from the power actually taken to drive an engine and do its work. At present, he believed there were no such figures accessible to most of them, at any rate he had found the greatest difficulty in getting any such figures that could be trusted. It was not possible to compare the efficiencies of one dynamo driven by a rope and another direct-driven; so many other questions came in besides the method of driving that the two could not be compared. But he hoped when these results were published, as they were going to be, they might all of them be a great deal wiser for them. Mr. Crompton had referred to a method of getting an accurate report of the engine load factor of the day. He thought that was in the power of all of them with extremely little measurement; if the output of each engine was metered and the number of hours that engine had run was also noted, they had the load factor of the engine for the day sufficiently for all practical purposes. He got that down as a regular matter week in and week out, so that they always knew the working load factor. It was a most valuable thing to know, and, of course, could be got in that way extremely easily. Then there were those "obscure losses," with which he was sorry to say his name was connected. He hoped he did not get more of them than others. He had measured them by running all the water that got condensed in the steam pipes into the sump and pumping it out and weighing it. That included everything that went into the pipes when opened up and that got there when shut down, and everything that warmed the pipes up and that they were responsible for. Running with light loads quite lately he had found it amount to more than 8 per cent. of the whole, and in other cases it was 5 per cent. and 6 per cent., and a little more. It was not so high proportionally in the winter, but it might be a very serious matter indeed, as anyone who took the trouble to measure it would find. He hoped Mr. Crompton did not mean by his paragraph on page 13 of the paper that he really doubted whether there would be any economy due to condensation. Although they might not care to put a positive figure to the actual amount of economy, he thought most of them who had tried it were convinced that there was economy in the use of condensation. He thought, in many cases, it might amount to 12 to 15 per cent., or something of that kind. He thought there was a little misunderstanding sometimes as to the effect of size of works on its cost. The cost of works, as everybody present knew perfectly well, was divided into two parts, the actual cost of generating at the works and a series of outside costs. Now, there were certain points in which a small station might have a great advantage over a large one. The actual generating costs, apart from wages and salaries, depended on the relation of units to load and on the shape of the load curve, and was independent of size of station. Wages and salaries per unit diminished to a certain extent as the station grew larger. However, when they came up, at a very rough approximation, to about 3,000 H.P., possibly 4,000, in the station they had got to a point beyond which, practically, they were not going to reduce anything in their cost per unit. He (the speaker) said this, he remembered, in the discussion on Mr. Ellington's paper, the author in that case having put the figure somewhat lower, he believed 2,000 H.P. After that they would find the actual cost would be very much the same whether their larger power was put into two stations or one, and whether one or two was preferable would depend upon other considerations. It might be more convenient to have one, but it would not make any particular reduction in the cost per unit.

Mr. SEGUNDO explained that his estimate of 4½ lbs. was per Board of Trade unit paid for by the consumer; the corresponding figure per unit generated would have been 3½ to 3¾ lbs.

Mr. HALPIN* said the first point he would remark on was the statement by Mr. Crompton that he considered the small and dust fuels only less valuable because part was liable to fall through the bars. They were all aware of the mechanical disadvantage of using fuel under those conditions, but he thought one very great source of loss in that fuel which was overlooked was oxidation. When disintegrated it became oxidised and naturally got much less valuable. The highest thermo-dynamic effects ever produced by the late Mr. Crampton was when his fuel was freshly powdered and before any oxidation could have taken place. Mr. Crompton said the locomotive boiler was not efficient on account of the level of the fire bars. Well, it was evident that it could not be efficient. In point of fact they had taken the locomotive boiler lock, stock, and barrel, and adopted it exactly and absolutely, like the Chinese. Quite recently in a central station he had seen a man firing where he had to lift the shovel up to the level of his shoulder, and after he had thrown the coal in he looked in to see what had happened. That was a state of things that might be easily got over. In 1872 some beautiful results were obtained by Clayton & Shuttleworth, at Cardiff, which had never been equalled either before or since. What they did was to carry the foundation ring along and instead of having it along the front of the box, they brought it up in horse-shoe fashion and got the fire bars lower down. Very much more efficient results might be obtained by bringing the fire bars down to a reasonable level, so that a man might fire the thing and see what he was doing. He had some figures which he would give them regarding the Babcock boiler. Mr. Crompton had given them some details which were perfectly reliable; but as he was able to identify the boiler he was referring to as the St. Pancras one he had taken the trouble to look up some further figures in connection with it. He had put some diagrams on the wall showing the evaporation from and at 212°, and also a curve showing the rate at which the boiler was working. If they were told a man was earning £100 or £1,000, without any limit of time, they knew nothing as to the extent of his income, but if they knew the man was earning £100 in a certain limit of time they knew everything; and in the same way they could try a boiler. If they found it evaporating 3 lbs. per square foot per hour and doing an evaporation of 10 or 11½ lbs., and if they multiplied those figures into one another, as they did those of elongation and work done in breaking stresses, they would get a curve giving them more light, showing rapidity of evaporation into the economy of evaporation; and such a curve showed that the Babcock was ahead of all its competitors as regards economy. He did not doubt that if they took the result of putting the speed worked at into it, it would come out different. But it was possible to pay too much for a sovereign, and if they had, as Prof. Kennedy had said, an economy of 11½ lbs. when they were burning only 6 lbs. of coal per square foot of grate, why that was simply doing nothing. Mr. Crompton told them one boiler was doing 50 per cent. more than its work without getting into trouble, but all he said was: Thank you for nothing; this particular boiler was doing under 3 lbs., and 50 per cent. more made it almost 4½ lbs. With regard to the Lancashire boiler, some trials were made by the South Lancashire Coal owners, some 30 years ago, with boilers 7 × 30 using northern coal. The tests were very accurately made, and these were the results, as the average of 60 trials: The boilers evaporated 7·1 lbs. per hour per square foot of heating surface. They were using coal with 11,670 units and doing an evaporation which reduced into thermal efficiency meant 827, which was a very big figure. So they got 7·1 × 825, and that gave them the figure of merit 5,871. Compare that now with the other boiler. The Babcock boiler he had taken was evaporating on that trial 2 893 lbs. per square foot per hour. The efficiency of the coal as given by Mr. Crompton was 766. Multiplying those two numbers together they got 2,245; that was to say they got 58 as the figure of merit for one boiler and 22 for another. He must go one step further. Mr. Rosenthal had given him the price of several of the Babcock boilers, and he had taken out what it came to in heating surface. The Babcock boiler had a great advantage in the way of cost. The average cost, which was very near for four or five boilers, was 6·21s. per square foot of heating surface. He had also obtained the prices of five standard Lancashire boilers, and their price was very much higher, 8·74s. per square foot of heating surface. So that now if they divided the results of the factors of efficiency—they had got by the prices of capital cost at which those figures were obtained—they got something like a final figure for the efficiency. If they divided this 58 by 8·74, they got a figure of merit of 655, whilst with the other boiler they got an efficiency of 354; so that the boiler which stood highest as to rapidity of work, for the economy at which it ran and capital cost was very nearly 2 to 1. And that was quite apart from all questions of the Lancashire boilers being able to use dirty water and smoky coal, which he hardly thought the other people would claim for their boiler, good as it otherwise was.

Mr. ROSENTHAL* said the previous speaker had reminded him that the discussion on Mr. Crompton's paper had resolved itself largely into a question as to which was the best boiler for a central station. During the last three or four years, a good many electrical engineers had thought that the best thing to do was to put in Lancashire boilers in a central station, particularly in places where coal was cheap, in the North of England, and where the question of space was of less moment. He had not been able to obtain any very complete data as to the results obtained in those places by Lancashire boilers, but the average experience in the North of England of the working of Lancashire boilers in ordinary factories certainly went to show that the result was not more than an evaporation, as a rule, of 6 to 7 lbs. of water per lb. of coal. There were trials on record, as Prof. Unwin had mentioned, of magnificent results obtained with Lancashire boilers. But those results were no criterion whatever for the design of a central station, because, excepting in a very few instances, it would not be possible to put as much boiler surface down in Lancashire boilers as would be required to work at such a rate as would ensure the efficiency that was held up as the possibility of efficiency obtainable with a Lancashire boiler. So that on the whole he thought that when an engineer designing a central station looked into the question, he would find that a much better boiler for his purpose was either a water-tube boiler or an ordinary tubular boiler. The question of safety, of course, had always to be considered, and

the question of upkeep likewise, and it was a very questionable thing whether a Lancashire boiler was under any condition a good boiler for high working pressure. He was not prepared to say it was impossible to construct a Lancashire boiler to work at high pressure, but he had certainly seen a good many put down to work at high pressure which had had their pressure reduced in a very few years and became useless. Whether any of the engineers who had put down Lancashire boilers would experience this also was a matter to be seen. As to the possibility of such high efficiency being obtained as Mr. Crompton mentioned, his figure was undoubtedly very high, and there might be a question as to whether it would pay in the long run to go to such refinement as was necessary to obtain such high figures. At the compressed air station in Paris, an indicated horse-power was produced with 500 grammes of coal, containing about 14,000 B.T.U., which was equivalent to $1\frac{2}{10}$ths per lb. of English coal, and only a day or two ago he received particulars of a plant of Babcock boilers in Calcutta, working in connection with a triple expansion condensing engine of 2,000 H.P., where the results amounted to the production of 1 I.H.P. with $1\frac{3}{4}$ lb. of Indian coal, about equivalent to $1\frac{1}{10}$ths lb. of Welsh coal, so that it seemed we were not very far off the figures that Mr. Crompton mentioned as possible. It was said sometimes that a Lancashire boiler was better than a water-tube or an ordinary tubular boiler in respect to the prevention of smoke. He mentioned both boilers because both were under the same conditions so far as the prevention of smoke was concerned. If they worked a Lancashire boiler very lightly indeed with a class of bituminous coal that easily coked, they could undoubtedly fire it to produce very little smoke. On the whole, they might take it that a Babcock boiler or ordinary tubular boiler, to burn bituminous coal smokelessly, required mechanical firing, and so did a Lancashire boiler. Mr. Halpin had given them a number of figures as to the evaporation per square foot of a Babcock boiler compared with a Lancashire boiler. Now, those who were acquainted with boiler construction, knew that for a given amount of work to be produced economically, you required more surface in every kind of tubular boiler than you did in a boiler in which the heating surface is merely plate surface, and he submitted that it did not matter to the electrical engineer what the surface of the boiler was so long as he obtained a certain quantity of steam for a certain quantity of coal and the total power he required cost him the same amount of money as it certainly would do if he took the rate of working of the Lancashire boiler to obtain the same efficiency as in the tubular boiler; it made no difference to him whether he got more surface for his money in one case than in the other. It was a question of the total production of steam for the amount of money. With regard to burning oil, he certainly thought that oil fuel would be used, to some extent, for dealing with sudden loads in an electric light station. There was no difficulty whatever in applying oil to an ordinary boiler burning coal, and it could be used at a moment's notice, but no such fancy results were to be obtained as Mr. Henwood had claimed, and so far as the wonderful type of boiler he had sketched was concerned, that was simply a Yarrow boiler with the tubes connected in such a way that they could not possibly be cleaned, and that would not do for an electric light station. The question of dryness of steam was one often discussed. Ten years ago, every engineer he met said "Oh, the tubular boiler gives wet steam." Well, he did not know how many cases there were of tubular boilers giving wet steam, but he thought they were very few. He certainly thought, from careful observation, that on an average, and working at the same rate, in the manner he had just explained, the Lancashire boiler did not give as dry steam as water-tube boilers did. He was not speaking of water-tube boilers constructed for light weights, such as on torpedo boats, for the conditions under which they were constructed and worked were altogether different. The last case in which he had heard of wet steam was at Deptford, and upon investigation it was found that the steam as it came from the boilers contained only $\frac{5}{10}$ths of 1 per cent. of moisture, and the wetness was produced in the steam pipes, which was the most prolific source of the trouble of wetness of steam in the engine.

Mr. Crompton* said he must, in view of the shortness of the time, keep his reply as brief as possible, and go more fully into details in the pages of the *Journal*. He thanked Mr. Raworth for his very cordial appreciation, and assured him that he did not address his paper to any of the gentlemen named by him, but rather to some of the gentlemen who had spoken that evening, the boiler makers, the Lancashire men in particular, and the makers of the long stroke slow speed engines in general. With regard to the Lancashire boilers, they were all of them right and all of them wrong. He perfectly agreed with Prof. Unwin as to the splendid results got on test runs from the Lancashire boilers, but he left out the very thing which Mr. Halpin supplied, the rate of firing. It was the high rate of firing occasionally necessary in an electric light station which made the Lancashire boiler comparatively inefficient. It was of no use trying to explain results away, and it was the fact that there was hardly a Lancashire boiler station which was doing well; there were exceptions, but they were due to the great skill and unwearying attention of the engineers in charge. As a matter of fact, you could get good results out of a Lancashire boiler with an economiser behind it to soak out the waste of units of heat during times the stoker was firing badly. There was not the same difficulty with the multi-tubular boilers of the locomotive, semi-marine or Babcock type. They had all done good service in their stations, and he would say at once, in reply to Mr. Halpin's remark about the good results of which he (the author) had spoken with the Babcock boiler, forcing it to 50 per cent. beyond its normal, that that boiler was 16 feet long 9 feet wide and 12 feet high, and was doing 600 H.P. He was speaking within the mark when he said that that class of boiler would stand forcing. Major-General Webber's remarks were nearly every one of them based on misapprehensions, and he was surprised to see how a man could so misinform himself. He had taken the trouble to argue at length on his (the speaker's) miscalculations in regard to capital cost, showing that it was impossible to be done at 2s. per unit, whereas he had stated in his own paper recently on the City of London Lighting that £75 per kilowatt was what was expected; he (Mr. Crompton) had taken it at £100. This was a fair specimen of the careless manner in which Major-General Webber had read the paper. The personal remarks of the same speaker he did not think it would be at all dignified for him to reply to. Mr. Robinson and others said his ideal figures were pitched too high. He might possibly be wrong in that respect, but he wished them to be high and difficult of attainment. He thought with Prof. Kennedy that $4\frac{1}{2}$ lbs. was reached every day now in some of the best stations per unit sold to the customers. If that was reached already, and as they knew there were very considerable and preventable losses still remaining, it was to be assumed that they would get $3\frac{1}{2}$ lbs., but beyond that he admitted it would be a very stiff pull; but why should he not give them $2\frac{1}{2}$ lbs.? It was absurd for them to go on like the old Matthiessen's standard of copper, having a 104 per cent. efficiency. He hoped Mr. Schönheyder would not misunderstand the remark he made about his water meter as to a higher efficiency being desirable. He had obtained better results with his meter than with any other, but this kind of meter had to work under such excessively hard conditions in using hot water. He would like to thank Mr. Hammond, who had himself done good service in preparing statistics, and knew the difficulties to be encountered in so doing. He (the speaker) would say at once that he had been met with uniform courtesy from everyone to whom he applied with one exception, and that was Major-General Webber. He was interested to hear Mr. M'Laren's remarks. Everyone knew that Mr. M'Laren was the builder of record engines, engines which had done very high duty, and he was especially pleased to hear that he was the builder of the engines at Oxford, where the results were so good. He wished to say that he never intended to throw any doubt on Mr. M'Lean's figures; he said they were "almost too good to be true," which was a form of expression often used regarding something that was exceptionally good. In this case the results were wonderful, and they were obtained in the proper way, that was, by measuring and watching everything and analysing the losses. That was the sermon he had endeavoured to preach to this Institution almost constantly for the past six years. He welcomed Mr. Barnett's remarks; he knew that gentleman to be a boiler-maker of exceptionally high standing, and as one who had given his thoughts to boiler economy to a greater extent than most people. He would answer the points which he had raised at length in the *Proceedings*. With regard to the remarks made that evening, he had already stated in answer to Mr. Segundo that it was not so impossible to get to his ideal; he admitted it was difficult, but not impossible. He thought Mr. Segundo forgot that Sulzer and other Continental makers had been getting 13 lbs. with condensing engines pretty regularly for some time past, and he fully expected to hear that they had done it in electric light stations. It might interest Mr. Segundo to know that even in high speed engines Messrs. Willans and Robinson were giving trade guarantees of $13\frac{1}{2}$ lbs. per H.P. He was very glad to welcome the remarks of Mr. Shoolbred and another gentleman who spoke on the subject of the advantage of using accumulator storage. That was a theme upon which he had harped, and regarding which many strong things had been said of him; but it was well known that, especially in the smaller class of stations, the saving in the wages account was very considerable from the use of accumulators, and the saving of coal by being able to run the engine at a better load factor was also considerable. He was glad to say they had brought this home to the American mind, and in New York some of the large stations were being worked by Howell accumulators, and they were getting an infinitely better supply of electric current at a lower cost. With regard to Mr. Dykes's remarks, he regretted the mistake in the paper, and he hoped he should be forgiven when he said that he fully intended to make the 93 per cent. correction communicated to him; that Table VI. was corrected some six or seven times, and he wondered that more mistakes did not get in. But this did not affect the figures except in regard to the units generated. He was very glad to hear what Mr. Dykes had said. He had no desire to animadvert upon the station, and he hoped some day they would be able to explain away what appeared to be a very large consumption. The information which Prof. Unwin had given was very valuable, especially that with regard to superheating steam. He had listened with great interest and had learnt a great deal. He had known for some time past that this was a development from which they would get greater economy. But he felt he was not quite right in saying that it was not one way, and a cheap way, of doing away with part of the losses in the steam pipes. He believed however carefully they lagged their pipes they could not get their losses down to the point they would like to get them to, but if they superheated the steam to 600° or 700° they would be able to get to the engine cylinders steam well above its equivalent temperature of saturation. He had already pointed out that the flue type of boiler required to be fired regularly in order to get the high results mentioned. He could corroborate what had been said regarding the advantages of the Economic boiler from personal experience. Prof. Kennedy had kindly refrained from criticism, and had given them valuable information which they required. In writing a paper, what the author ought to do was to put into the hands of those who wanted it all the information possible on the subject, but one always hoped to get as much information out of the discussion as out of the paper itself, and when they had such speakers as Profs. Unwin and Kennedy that object was gained, and he must congratulate himself upon having got that information out of those two gentlemen. One of the most important points that had been raised, to his mind, was that mentioned by Prof. Kennedy, who said he had noticed that when they got to 3,000 or 4,000 H.P. they had reduced the generating cost almost as much as they could possibly do. That was a thing he had wished to say himself for years past in the old controversy about putting large stations outside the town instead of

having smaller stations inside a town. It apparently never struck those who had been urging this great change that there was no advantage gained in making the size of a station above a certain figure, a figure which Professor Kennedy had put at 3,000 or 4,000 H.P., and with which he perfectly agreed. Several speakers had thrown doubt upon the possibility of the use of liquid fuel being carried out successfully. He thought the peculiar conditions of electric lighting, with that popular peak on the curve, in every way pointed to the use of liquid fuel, and also the very rapid rate of evaporisation in the boiler which could be given with liquid fuel. His own company and one or two others, were experimenting in this direction, and no doubt when next a paper on this subject was read before this Institution, they would have successful results to record. It appeared to him that if one could call on a second boiler at 20 minutes' notice and heat it up, as he had seen done with the use of liquid fuel, they were having an ideal state of things as regards boiler plant in an electric light station; and he might say that the introduction of liquid fuel would, in his mind, increase the possible output of many existing London stations some 40 or 50 per cent., for in nearly all those stations the future limit of expansion was bounded by their boiler power and not so much by their steam power. The interest taken in the paper repaid him in every way for the trouble he had had in writing it, and he could only repeat that his object was to elicit from those who knew the subject best, that was to say, those who worked in those stations, what their real opinion was on the progress of their art, and he thought they had every reason to be satisfied with the progress which had been reported to them, and at getting such figures as Prof. Kennedy had given them of 4¼ lbs. of coal per unit delivered to customers.

The meeting was then adjourned until next session.

TELEGRAPHS AND TRADE ROUTES IN PERSIA.*

By Lieut.-Col. HENRY L. WELLS, R.E.

The Indo-European Telegraph Company comes from London *viâ* Lowestoft, Emden, Berlin, Warsaw, Odessa, Kertch, Sukumkaleh, Tiflis, enters Persia at the passage of the River Araxes, which forms the frontier between that country and Russia.

The company's lines are well constructed and admirably maintained. The Persian portion of their system traverses a very elevated plateau; for instance, at Zenjan, the whole surface of the country has an elevation varying from 5,000 to 6,000 feet above the sea. The distance from Djulfa, where the line crosses the Araxes, to Teheran is 440 miles. The line runs parallel to the main mountain chains, which protect it from the north winds. Throughout the above-mentioned distance the altitude of the country passed over by the line does not vary more than 3,000 feet. This fact, together with that of its being protected by the mountain ranges, accounts for the singular immunity from interruptions it enjoys.

All the three wires of the line are now carried on porcelain insulators, supported on malleable iron brackets, which are bolted round the Siemens standards. The third wire is for the use of the Persian Government.

At Teheran, the capital, the Indo-European Company's administration terminates, and that of the Government commences. There are about 25 members of the joint staff stationed here.

The Indo-European line runs south from Teheran to Kom, skirting the great desert on its western extremity.

From Kom the line skirts the desert to Kashan and passes through villages which used to be liable to be pillaged by Turcomans. The altitude of Kom is 3,100 feet. From Kashan, which has an altitude of 3,200 feet, the line following the shortest route to the south rises 5,500 feet in 32 miles to the summit of the Kohrud Pass, which has an altitude of 8,750 feet. This is a difficult piece of line to keep free from interruption during winter, and it took several years to find the best direction for the wires and overcome the difficulties due to the intricacies of the rock-bound defiles and the sudden gusts of snow-laden wind that rush through them. On the summit the snowfall is so great that the standards have to be only 60 yards apart. There is no habitation between Kohrud, which is situated on the northern slope of the Pass, and Soh, which is situated 20 miles away at the southern outlet from the mountains.

Soh is the head-quarters of an inspector, who has a length of 247 miles to look after.

At Ispahan, Her Britannic Majesty's Consul and the bankers are the only Europeans who are located in the city itself. The telegraph office and the residences of the merchants are in the Armenian suburb of Djulfa.

From Ispahan to the water shed at Dehbid the line runs in a south-easterly direction, and is protected by mountain ranges. Koomeshah is the head-quarters of the inspector of the second sub-section, which extends from Ispahan to Meshad-i-Moorgab, a distance of 195 miles. This inspector and his working parties are liable to annoyance from robbers, who infest this part of the road at times of political disturbance, such as that which occurred in 1892.

Europeans and Persians, who have to go out on interruption duty, suffer greatly from the hardships they undergo. Persian gholams, or line riders, follow the Englishmen with the utmost devotion. To show what determined men they are, and how they remain in the service as long as possible, I may mention that, up to 1893, only one gholam had lived to enjoy a pension—he having been disabled by snow blindness—others who have not died in harness have, on resigning, not survived to draw the pension they have earned. There is, however, one man now drawing a superannuation pension, and he is the first that has done so.

The line passes within two miles of the ruins of Persepolis, and 40 miles further on Shiraz is reached.

The people of this city are a high spirited, turbulent set; faction fights are of frequent occurrence among them. An old palace does duty as telegraph office, one end being occupied by the British, and the other by the Persian administration. A square in front of the palace is a favourite site for political and other disturbances.

When a disturbance breaks out the first point generally made for is the Persian telegraph office. The popular leader demands that a petition embodying the wrongs of the citizens shall be despatched to the Shah. If a reply is not quickly forthcoming, the mob usually ousts the Persian telegraph officials and wrecks the office, or, at all events, renders the instruments useless. A move is then made for the British office, and a message is dictated to the superintendent, who has to forward it to the director in Teheran, who hands copies of it to Her Britannic Majesty's Minister, the Grand Vizier, and the Persian Minister of Telegraphs, and consults with them with a view to obtaining protection for his staff. The senior British telegraph official at the sending station then becomes practically a hostage in the hands of the mob. In the very serious riot which took place in the spring of 1893, Mr. Fargues, the superintendent, was so detained, and was not allowed to leave the office precincts for five days. The local governor was powerless to afford protection, what troops he had having fraternised with the insurgents. Not a moment's delay occurred to the international messages, and not the slightest damage was done to the British office on this occasion.

There is but one solitary instance of the *personnel* of the telegraph department being made to suffer with the object of attaining political ends. The case occurred at Shiraz. A telegraph official, with his wife and friend, were set upon one evening when proceeding from the telegraph quarters to the city; the ruffians fired on the party, and then made off; the lady was seriously wounded, the culprits were never discovered, but their object evidently was to discredit the governor who then ruled in Shiraz. Compensation was paid, and much regret expressed for the dastardly outrage by the governor.

It was from Shiraz that Mr. J. R. Preece was despatched in January, 1884, to report on the practicability of a landline *via* Darab, Forg, Tarum to Bundur Abbas, a distance of 550 miles, and the country between that place and Jask. He found no physical obstacles to such a line, which, if constructed, would complete an aerial wire from India to the North Sea.

When a line to link Jask by land to the Persian section is again under consideration, it would be well to have the country between Kazerun and Bunder Abbas surveyed. It is probable that a very suitable way will be found along the southern slopes of the great mountains which form the boundary of the Persian plateau in that direction. The advantage of this route would be its freedom from snow and its close proximity to the gulf and to British influence.

From Kazerum to Behbaham, and thence to Ahwaz and Bagdad, would be the best route for a line to join up with the Mediterranean cables *via* the Euphrates valley. The country from Kazerun to Ahwaz is perfect for the purpose, and I must say that it seems to me that the Euphrates valley and Southern Persia is the best route for another line of telegraphic communication with India.

The third sub-section extends from Meshad-i-Moorgab to Mian-Kotul, a distance of 131 miles. The portion of this section which is south of Shiraz, is the one where the snow fall is greatest; the damp clouds from the Gulf discharge themselves in the winter in this elevated country.

The fourth section extends from Mian-Kotul to the sea, and is the only one which is below the winter snow line—distance 102 miles. The total length of line is 675 miles.

Lines.	Length in English miles.	Date of completion.
1. Teheran to Bushire (English Government line of three wires; one wire is reserved for Persian traffic)	675	1864
2. Teheran to Khanegin (constructed by English Government; handed over to Persian Government, 1870)	440	1864
3. Teheran to Summer Palaces of H.I.M. the Shah	18	1865-67
4. Kasvin to Resht	105	1869
5. Teheran to Djulfa (Russian frontier); constructed by Siemens; three wires, one reserved for Persian traffic	415	1870
6. Teheran to Shâhrûd and Astrabad	314	1870
7. Merend to Khoi	35	1872
8. Hamadan to Dowletabad, Burujird, Sultânâbâd	120	1874
Total length of lines	2,122	...

No physical difficulties for a telegraph line exist. The inhabitants, however, are very troublesome. They still continue to damage the standards by using them as targets to test the penetrating power of their rifles.

* Abstract of paper read before the Society of Arts.

The Persian section ends at Reshire, the work being there taken up by the Persian Gulf cables.

With regard to the lines of the Persian Government, the first was erected from Teheran to Sultanieh in 1859, but it was demolished within the year. Next a line was made from Tabriz to Teheran in 1860, and was continued to the Russian frontier in 1863. In 1864 the Persians were able to utilise their powers and work over the English Government line from Bushire to Teheran, and on to the Turkish frontier at Khanegin. Year after year new lines were opened, till in 1877 the Persian Government lines were as given in the Table.

The Turkish lines have been joined at Bashkaleh and Kanigin; those of Russia at Astra, *via* Resht; and those of the Trans-Caspian system *via* Astrabad and Sarakhs. Excepting a small part near the Turkish frontier, all the lines are carried by wooden poles, unseasoned poplar being the material most usually employed. These, of course, become rotten in a very short time, and are peculiarly liable to destruction by white ants. Struts are never used; wire stays are often placed within a few inches of a practically uninsulated line, and thus afford a fruitful source of leakage. There are very few insulators; those fixed are of various patterns; most of them have been made at Teheran, and all of them are practically useless; at all events in wet weather the lines will not work. On dewy nights they also would be unworkable; but as the offices only remain open during the day, this does not matter.

The instruments are of all sorts of patterns, but the greater number are sounders with polarised relays. Of the above lines, the only ones that are reliable and efficient are those maintained for the Persian Government by the European administration, namely, that from the Russian frontier to Teheran, that from Teheran to Bushire, and from Teheran to Meshad.

The grave difficulties under which the Persian Government Telegraph Department labour are—1st, want of education; 2nd, want of public spirit and discipline; 3rd, want of proper pay and promotion; and 4th, want of a proper system of inspection. His Excellency, the Mukhber-ed-Dowleh, K.C.I.E., the Persian Minister for Telegraphs, is an able man, who is anxious to do the best he can with the means at his disposal. It is, thanks to his good will and never-tiring exertions for the welfare of the Indo-European lines, that they have achieved such success in the Shah's dominions.

On the Bagdad-Teheran line for miles the wire has no insulators. At one place I counted as many as nine joints in the wire in a length of 85 yards. The joints are shamefully made; are absolutely innocent of solder; the wire is simply twisted by the fingers, and often rests on the ground.

Occasionally poles that have rotted at the bottom are shortened and replaced, and thus have only a height, say, of 7 feet. Sometimes, where the wire had fallen out of the insulator, it was found spiked to the pole, just as high as the gholam could reach. Thus a saving of labour in climbing the pole is secured at the expense of affording a dangerous obstacle to a horseman should he wander off the track at night.

The instruments and batteries seen were, for the most part, in a disgracefully dirty condition, and some of the operators were evidently addicted to smoking opium.

Gradually, by substituting poles of cyprus wood—which white ants do not touch—for those of poplar, by cutting out the bad wire and making good joints, fitting up the offices and renewing the instruments, and, by transferring the utterly worthless members of the staff, the period of interruption has been reduced from 1,600 hours in 1887 to 543 in 1893.

The line suffers most severely from camels. These animals, when casting their coats in the autumn, go for the telegraph line. Their apathetic keepers never think of protecting Government property, and so it is only a matter of time ere the poles are effectually loosened, or even thrown down. Nothing but iron standards, with spreading foot plates, will overcome this difficulty. Instances have occurred of the soldiers of a regiment on the line of march from Meshad helping themselves to telegraph poles in default of other fuel. As there is no arrangement, except one on paper, by which the local governors are made responsible for the safety of the line, it is at present impossible to obtain any protection for it: any passing traveller who wants a bit of wire helps himself from the line; anyone who wants wrought iron helps himself by smashing an insulator, and taking the bolt; 2,000 insulators per annum are so smashed.

If this line is to be kept up, and in the future prolonged through Herat and Candahar to the British frontier at Chaman, it must be entirely reconstructed with Siemens's iron standards ere it can be considered an efficient or thoroughly reliable means of communication.

NEW PATENTS—1894.

9,844. "Improvements in gas and oil engines." A. E. JERRAM. Dated May 21st.

9,862. "Improvements in batteries." W. MORISON. Dated May 21st. (*Complete.*)

9,896. "Improvements in the arrangement of gearing for electrically propelled vehicles, cars, yachts, and launches." G. W. LEECH. Dated May 22nd.

9,909. "Improved shade-carrier for gas and electric shades." E. W. LANCASTER. Dated May 22nd.

9,927. "Improvements in electrical switches and connecting to the same." E. J. PIPER. Dated May 22nd.

9,930. "Improvements in signalling on railways, and means therefor." THE AUTOMATIC ELECTRIC RAILWAY SIGNAL COMPANY, LIMITED, E. BLAKEY, and J. P. O'DONNELL. Dated May 22nd.

9,934. "Self-generating electro-magnetic motor for driving power." G. E. ADAMS. Dated May 22nd.

9,949. "Improvements in electrolytic apparatus." T. CRANEY. Dated May 22nd. (*Complete.*)

9,967. "Improvements in electric arc lighting." C. A. DAY. (Communicated by The Higham Electric Company, United States.) Dated May 22nd. (*Complete.*)

9,968. "Improvements in the method of and apparatus for arresting motion of electrically-propelled mechanisms." E. A. SPERRY. Dated May 22nd. (*Complete.*)

9,974. "Improvements in or relating to apparatus for heating metals electrically." W. P. THOMPSON. (Communicated by C. L. Coffin, United States.) Dated May 22nd. (*Complete.*)

9,975. "Improvements in the method of and apparatus for heating, welding, or working metals by electricity." W. P. THOMPSON. (Communicated by C. L. Coffin, United States.) Dated May 22nd. (*Complete.*)

9,999. "Improved holder for incandescent lamps." W. MCGEOCH, Jun., and A. W. STEWART. Dated May 23rd.

10,018. "Improvements in electroliers or lamps of the kind chiefly employed and known as extension or floor lamps but applicable to other lamps." W. SOUTTER. Dated May 23rd.

10,021. "Improvements in connection with primary batteries and portable electric lamps." S. W. MAQUAY. Dated May 23rd.

10,032. "Improvements in and connected with electrolysis and in apparatus connected thereto." E. GAUTIER. Dated May 23rd.

10,044. "An improved system of producing luminous electric changeable writing and in apparatus therefor." A. THEODOLI. Dated May 23rd. (*Complete.*)

10,045. "An improved method of and apparatus for controlling the action of electric motors and other prime movers." J. B. ORMSBY and G. H. BANISTER. Dated May 23rd. (*Complete.*)

10,052. "Improvements in Portland cement in union with petroleum; for the incandescence of electrical gases; in man's, animal's, and bird's excrescences in air, land, and water." W. H. HUGHAN, Sen. Dated May 24th.

10,101. "An improved gripping tool for electric light and other fittings." G. BINSWANGER and W. E. GIBSON. Dated May 24th.

10,114. "An improvement in incandescence electric lamps." B. PELL. Dated May 24th.

10,115. "Improvements in electric lamps for surgical purposes." A. C. COSSOR. Dated May 24th.

10,132. "Automatic zero reading electrical instruments." J. EDMONDSON. Dated May 25th.

10,140. "Improvements in regulators for electric currents." W. HARTNELL. Dated May 25th.

10,149. "Improved apparatus for supporting electrical conductors and the like." J. ORME. Dated May 25th.

10,165. "Improvements in engine-room telegraphs and the like." V. RUSS. Dated May 25th.

10,169. "Improvements in plates for secondary voltaic batteries." G. R. BLOT. Dated May 25th. (*Complete.*)

10,171. "Improvements relating to writing telegraphs." P. A. NEWTON. (Communicated by E. Gray, United States.) Dated May 25th.

10,172. "Improvements in or connected with vehicles for electric railways or tramways." E. HOPKINSON. Dated May 25th.

10,186. "Self-locking cleats for electric wires." E. NASHOLD. Dated May 25th. (*Complete.*)

10,199. "An improvement in the art and process of electrotyping." J. W. NAUGHTON. Dated May 25th. (*Complete.*)

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1893.

7,782. "Improvements in electric cables." G. G. M. HARDINGHAM. (A communication from the firm of Felten & Guilleaume, of Mülheim.) Dated April 17th. Several conductors and a body of insulating material, which may be merely a flat strip, or may be cross-shaped or star-shaped in transverse section, are twisted together, the several conductors lying in the respective grooves of the insulating material, and being thus separated from one another. 9 claims.

8,004. "Improvements in or connected with electro-motors, more especially applicable to the propulsion of vehicles." E. DE PASS. (Communicated from abroad by M. Johannet and G. Dupont, both of Courbevoie, France.) Dated April 20th. Relates to a special mode of transmitting force, whereby two shafts can be driven at any speeds by connecting one of them to the armature and the other to the field magnets of one and the same electro-motor, the said field magnets being made revoluble. 4 claims.

8,315. "Improvements in switches for electric currents." A. G. NEW and A. J. MAYNE. Dated April 25th. The principal features of this novel high tension switch are that it enables a perfect and reliable break to be made in the circuit with a much greater economy of space than has hitherto been found possible, prevents the possibility of an "arc" being formed when the switch is broken, and gives a high degree of insulation between the points with which the switch establishes and severs connection. 3 claims.